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Imperial Institute of Agricultural Research, Pusa

(Including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert, and Secretary, Sugar Bureau)

1930-31

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REPORT OF THE DIRECTOR.

(B. A. KEEN, D.Sc., F.INST.P.)

I. RESEARCH AND PROGRAMME OF WORK.

This portion of the report has consisted, in previous years, merely of summaries of the reports from each Section of the Institute. In the present report a different plan is adopted ; an attempt is made to discuss the main researches, to show their bearing on the problems of Indian agriculture, and also to indicate how the future programme of work arises, to a large extent, as a natural corollary of work already in progress. With the same idea in view, the proposed programmes of work in certain of the sectional reports have been given in more detail than in past years.

The basic purpose underlying the research work is the search for knowledge, which can be used for making practical advances in agriculture, and in improving our understanding of existing practices. Sometimes the practical application of new knowledge is immediate, but, more often, it has to await the completion of other, and apparently unrelated, investigations before the agricultural significance can be seen. A further point, fully appreciated by agricultural scientists, but often overlooked by others, is that even in cases where the agricultural significance of some piece of research is obvious, further investigation may be needed to ascertain the best method of employment on the field scale. These investigations necessitate full acquaintance with practical agricul-

tural conditions, which vary widely in different parts of the country. No central institution could ever undertake this work which is, in fact, the special sphere of the provincial centres.

The Nitrogen Problem.

Indian soils have, in general, a low content of nitrogen, and the ryot uses little or no nitrogenous manures. The climatic conditions, however, result generally in active nitrification, and the crop yields show little sign of deterioration although, in comparison with many other countries, the average yields are low. Studies of the nitrogen balance-sheet, the factors influencing nitrification, and practical measures such as the use of leguminous crops and green manures, are therefore of great interest and importance.

There is abundant evidence, from the Pusa field experiments and numerous trials elsewhere, that nitrogenous manures give an increased yield. Thus, in a series of plot experiments conducted by the Chemical Section at Pusa, on which various manures were applied to the *kharif* (summer) crop only and on which both *kharif* and *rabi* (winter) crops were grown, a preliminary examination of the results for the past six years shows a consistent increase over the control when nitrogenous manures are given, either alone or in combination with mineral manures. But for numerous reasons the use of artificial fertilisers will extend only slowly in India, and this fact focusses attention on the possibility of extending the use of organic manures, both to increase the total nitrogen-content and to improve the general condition of the soil. There is little hope of increase in the meagre quantities of farmyard manure at present used until (*a*) some alternative source of fuel is used and (*b*) some form of "mixed" farming (*i.e.*, the welding of arable agriculture and live-stock into one system) is generally adopted.

Hence, at present, the most likely means of soil improvement are the use of suitable leguminous crops in a rotation, and green-manuring. Reference was made in last year's report to the rotation under test by the Bacteriological Section. The results are not yet complete, but they suggest that although a gain of nitrogen is obtained when the nitrogen removed in the crop is taken into account, the amount in the soil has decreased. The possibility that this is due merely to a seasonal fluctuation cannot be determined till the experiment has been running for some time longer.

Green-manuring provides, therefore, the most immediate possibility, in spite of the reluctance of the ryot to grow anything which is not directly utilisable either for sale or for consumption. The Bacteriological Section has tried, on the field scale, alternatives to sann-hemp, the seed of which is dear. *Urid* (*Phaseolus radiatus*) and soy-bean were

compared with sann-hemp as green manures in their effect on the yield of the following crop—wheat or potatoes—and little difference was found. Seed rates for *urid* and soy-bean are cheap, and hence these plants should provide a suitable alternative to sann-hemp. A large-scale field trial will be made this season.

The Bacteriological Section has made an interesting experiment on the possibility of securing green manure on land already growing another crop. On a small area growing onions under irrigation, Mexican sunflower was also planted. Expressed in yields per acre, 66 maunds (5,431 lb.) of onions were obtained as well as sufficient sunflower to manure four to five acres. A small-scale trial of sunflower as green manure, against sann-hemp, showed that a 11 per cent. greater yield of wheat was obtained. There seem to be considerable possibilities in the method, for if the ryot can secure a reasonable yield of some staple crop and at the same time, and on the same land, obtain an appreciable quantity of green manure, one of the main economic difficulties in securing an extension of green-manuring will be removed. There will be undoubtedly practical difficulties as well, for the scientific aspects of green-manuring are not, as yet, completely understood. Work in this direction is very necessary if the Agricultural Departments are to be in a position to advise the cultivators with confidence as to the best methods of green-manuring under various soil and climatic conditions. The first essential is to study the biochemical changes following on the addition of green manure—with and without mineral manures—to the soil, and to compare them with the action of farmyard manure in the same conditions. This research has been begun in the Chemistry Section, and the results are being correlated with the yield of the subsequent crop, in a series of pot experiments.

Mineral Manures.

The restricted use of mineral manures has already been mentioned. The statement applies, of course, primarily to the ryot's system of agriculture and not to the estates of planters and the more enlightened zemindars. Pusa, in common with the provincial centres, has for some time past conducted field experiments with mineral manures, not only for the purpose of supplying planters and zemindars with information and advice, but with the idea of encouraging the use of manures among the ryots and thus raising the level of their crop production. Unfortunately most of these field experiments are unsatisfactory in design, and it is very desirable that they should be remodelled in accordance with recent developments in statistical methods, so that a greater degree of reliability can be attached to the conclusions. It is hoped that the services of a Statistician trained in the design of agricultural field experi-

ments may be secured for this purpose at Pusa in the near future, for the results of the various field experiments suggest important conclusions some of which can only be confirmed, or denied, if the experiments are repeated in a proper design.

The need for phosphates. Among the results which by reason of the magnitude of the increased yield are extremely significant, are the effect of nitrogenous manures, and of phosphates. The latter is especially interesting, for it suggests that phosphate may be a limiting factor in crop production over a wide area of Gangetic alluvium typified by the Pusa soil.

The lack of readily available phosphatic rock directs attention to alternative sources of phosphate, such as bones, large quantities of which are exported annually. The use of bone-meal is of course well known, but it is possible that there would be a demand for crude bones, provided they could be crushed inexpensively and provided, of course, that the prejudice of the ryot can be overcome. The Chemistry Section has therefore conducted trials with simple and cheap chemical agents which will soften the bones so that they can be readily crushed on the farm by the ryot himself. A mixture of 1·5 per cent. of caustic alkali with 1 per cent. common salt was found to reduce some 75 per cent. of the bones to an easily friable material within two months.

The apparent depression due to potash. One of the most suggestive indications of the field experiments is the apparent ineffectiveness, or even depressing effect, of potassic fertiliser on the yield. Although, for the reasons already stated, the experimental design does not permit the degree of reliability to be estimated, the indication is brought out not only by the permanent manurial plots on the farm, but by the separate plot experiments conducted by the Chemistry Section. The broad results are that whereas superphosphate, alone or in combination with ammonium sulphate, gives marked increases in yield, potash with ammonium sulphate gives distinctly inferior increases, little better in fact than with nitrogen alone; further, potash alone actually exerts a depressing effect, the yield being consistently below that of the unmanured control plots. The immediate practical importance is obvious; if the conclusion is confirmed by properly conducted field experiments, it will not, in general, be necessary to include the relatively expensive potassic fertilisers in the official recommendations for mineral manuring. It is, therefore, particularly interesting to note that the effect in question does not appear to be confined to the type of soil represented at Pusa; through the courtesy of Imperial Chemical Industries (India), Ltd., the results of their careful and correctly designed manurial experiments throughout India have been made available for examination. The results show that, almost without exception, no benefit in yield has resulted from the inclusion of potassic fertiliser in the mixture; further,

expressed in terms of money values, the relatively high cost of potassic fertilisers has converted what would have been a modest profit into a definite loss.

It is well known (for many crops of temperate climates at any rate) that potash manures have a beneficial effect on the quality of the produce, and it is this aspect which should now be explored by agricultural scientists in India. The subject of the quality of Indian agricultural products is, however, hedged around with difficulties which are inherent in the present conditions of Indian agriculture. This matter is discussed in detail in the next section of the report.

The Quality of Agricultural Produce.

One of the most significant movements in agriculture during the past few decades has been the introduction of definite grades or standards of quality for staple products, many of which, *e.g.*, wheat and cotton in the United States of America, have now the force of legal sanction behind them. In general, these standards deal with what may be called visual criteria of purity such as, in wheat, the absence of foreign matter, weed seeds and defective or diseased grains. In addition to these requirements, the trades or industries employing certain agricultural products have developed their own standards of quality : the ' strength ' of wheat flour is of vital importance to the millers, the malting quality determines the price offered for barley by maltsters, and so on. We seem, in fact, to be approaching the time when the agriculturist whose produce does not reach a certain standard will be driven from his present markets. Both from the standard of visual purity and of quality, Indian produce in general is defective. Some of the most basic causes, such as the impoverished state of the ryot, his indifference to the advantages (and the responsibilities) of co-operative marketing, lie outside the direct sphere of influence of agricultural research institutions. However, science can greatly assist the movement towards improved quality by ascertaining, in laboratory investigations, on what factors the buyer bases his empirical judgment and tests of quality, and then, by appropriate changes in agricultural methods (*e.g.*, in manuring) or by breeding new varieties, producing crops which will pass these tests.

In India the laboratory investigations indicated above have so far been of less importance than the *ad hoc* efforts of the plant-breeders, who have achieved already an encouraging degree of success, as will be seen by the following examples from the work at Pusa.

Wheat. Milling and baking tests of flour from some wheats bred in the Botanical Section, Pusa, were made, at our request, by the Research Association of British Flour Millers. The wheats for these tests were grown at Pusa and also at Mirpurkhas (Sind) under dry and irrigation

conditions respectively, and the milling tests were extended, for purposes of comparison, to some improved Sind wheats and a sample of ordinary commercial Karachi wheat.

The outstanding result was the success of P. 111 grown at Pusa. It was equivalent in value to good Manitoba wheat; it milled more easily than most hard wheats and gave a high yield of flour. The report states that, if it can be successfully grown in India, it will be of commercial importance as a 'strong' wheat. Millers need both 'strong' and 'weak' wheats to secure, by mixing or blending, flour of given baking properties. Two of the Pusa samples grown in Sind (P. 12 and P. 114) had high blending value, and from all points of view were classed as superior to the ordinary commercial Karachi wheat used in England for blending.

Further proof of the value of Pusa wheats is given by the results of the 1927-28 milling and baking tests of world wheats carried out by the United States Department of Agriculture: the variety P. 4 grown at Tarnab, North-West Frontier Province, gained first place.

It is unnecessary to stress the importance to Indian agriculture of the above results.

Barley. A preliminary examination was made by the Chemical Section of the malting value of some of the types bred in the Botanical Section. Type T. 24 compares well with Plumage Archer received from England some years ago and grown on at Pusa :—

	Extract Brewer's lb. per standard quarter	Diastatic activity	Tint		Cold water extract
			Yellow	Red	
Pusa T. 24	8·81	76·92	3·5	1·7	32·38
Plumage Archer . . .	8·36	76·92	8·8	3·6	39·90

Tobacco. With the exception of the cigar industry in South India, the indigenous types of tobacco are of value only for local consumption. The leaves are generally cured on the ground and in the open, and the product is coarse and strong in quality. The ever-increasing demand for a lighter and brighter tobacco, which is mainly associated with the rapid extension of cigarette smoking, has directed attention towards improvements both in the plant and in the methods of curing. The Botanical Section began in 1924 with a cross between a local type (T. 28) and an American Adcock, and has evolved 10 hybrids which are now fixed and are breeding pure within narrow limits. Of these, Nos. 142 and 164 were compared with an indigenous type (T. 49) in their behaviour under flue-curing in the barn. No. 142 yellowed quickly and gave the

highest percentage of yellow leaves yet obtained in these tests, while T. 49 confirmed the previous experience that none of the indigenous types can be cured to the necessary bright yellow colour. It is evident, therefore, that the latter will be replaced by the Pusa hybrids to the extent dictated by the increasing market for bright tobacco.

Meanwhile, the Chemical Section is continuing its work on the relation of the changes taking place during various methods of curing to the quality of the cured leaf. The country method of curing on the ground was taken as standard and compared with simple modifications which do not necessitate the cost of barn and flue-curing, and which, if shown to be superior to ground-curing, will be suitable for adoption by the small grower. The modifications were :—

(*a*) Sun-cured on racks protected from dew.
(*b*) Sun-cured on racks unprotected from dew.
(*c*) Sun-cured on racks, unprotected from dew 3 days, protected 10 days and finally shade-cured.
(*d*) Shade-cured on racks protected from dew.

Examination was made of the ratio of albuminoid to amide nitrogen, and the ratio of ash (mineral matter) to potash ; these ratios convey a general idea of the quality of the cured leaf, since the conversion of albuminoids to the harmless or even beneficial amides is a primary necessity in the fermentation, and the 'fire-holding capacity' depends on the presence of compounds of organic acid with potash, and a minimum amount of inorganic salts. The results show that, although no definite choice could be made between the four methods, they were all superior to the country custom of ground-curing. The common feature to the four methods was the use of a rack, and this inexpensive device can therefore be recommended to the small grower. It is possible that the advantage of rack-curing over ground-curing is not entirely a matter of aeration and temperature during the fermentation. In ground-curing the leaves are not removed from the stalk beforehand, hence the reserve of moisture in the stalk may extend the life of the leaf in the early stage of curing, leading to a greater diminution of its food materials, either by direct utilisation or by transport to the stalk. The effect of the presence or absence of the stalk on the process of curing will therefore be studied in the Chemical Section in the coming year.

The Yield of Agricultural Produce.

The need for increased yields of the staple crops of India is of no less importance than the improvement of quality discussed in the preceding section. Although, in present world economic conditions, with unsaleable gluts of foodstuffs, commercial fibres, rubber, etc., the case against over-production seems proved, this is a very different matter

from the question of improving the yield per acre. Since much of the total funds available for agricultural research in India is used in efforts to increase yields, it is desirable to deal with the possible objection that in present conditions this money is wrongly expended.

There are two conclusive answers : one of which is of general application, while the second is specific to India. Taking the latter first, there is little doubt that a large proportion of the population (and of the animals) is underfed. As the greater part of the foodstuffs consumed in India is, and must continue to be, grown within the country, it is essential that the level of crop production should be raised, so that adequate supplies of foodstuffs may be available for the ryot ; there can be no lasting improvement in the amenities of village life, and in the mental outlook of the rural population, so long as their bodies remain under-nourished.

The second answer, which is of world-wide application, is based on the fact that when real over-production of some agricultural commodity occurs, economic laws operate inexorably, and the total production becomes reduced, by the successive and automatic elimination of the less efficient areas, until the supply is no longer in excess of the demand. The efficiency of an area can be simply measured by the cost of producing one unit of produce, and the lower this figure, the less likely is the area in question to succumb to competition in times of over-production. Efficiency is increased in one or both of the following ways : by reducing the cost of production for a given yield of produce, as in North America and Australia where a few highly paid workers using labour-saving machinery can deal with a large area of crops ; or by obtaining a larger yield of crop for the same, or a little extra, expenditure of money and labour. The abundance of manual labour, and, above all, the minute size and fragmentation of many of the holdings, are effective barriers to the spread of labour-saving machinery in Indian agriculture except in favoured areas ; hence the immediate hopes of improving efficiency lie mainly in the direction of increasing the yields. The apparent paradoxical conclusion that, in times of over-production of some crop, attention should be devoted to producing still more of it, is soon resolved if one keeps firmly in mind the fact that the inefficient areas succumb soonest in the intensified struggle for existence. Further, quite apart from the special conditions obtaining in times of apparent or real over-production, there is in normal times a steady improvement in efficiency in all phases of agriculture; any country that follows a policy of *laissez-faire* must inevitably fall behind the more progressive ones, and be faced with the loss of its export markets and increasingly severe competition in its own home markets as well.

There are numerous methods of increasing the yield of crops, which can be grouped under the following broad headings : (*a*) improving

the soil conditions, (*b*) increasing the food supply of the plant by suitable manuring, (*c*) the breeding of improved and higher yielding varieties, and (*d*) the prevention and control of plant diseases and damage from insect attacks. With the exception of (*b*) which has already been considered under ' The Nitrogen Problem ' and ' Mineral Manures,' the contributions which Pusa is making to each of these subjects are discussed below.

Improving the soil conditions.

As the work at Pusa on suitable rotations and the use of green-manuring methods has already been mentioned in this and previous reports, it need not be referred to again, except to remark that the improvement in tilth resulting from adequate supplies of organic matter is an important factor in maintaining healthy plant growth without which good yields are not possible.

It is appropriate to consider, under the heading of soil improvement, the work recently begun in the Chemical Section on the characteristics of soil which is about to be put under perennial irrigation. An understanding of the important physico-chemical changes taking place in these conditions is most desirable, so that the precautions necessary to prevent future deterioration may be foreseen. In view of the large area in Sind about to come under perennial irrigation, arrangements were made to examine the soil from the ' Kalar ' area of the Experimental Farm at Sakrand, and thanks are due to the Provincial Officers concerned for their ready assistance, and their willingness to enter into co-operation with Pusa. The work is still in the preliminary stages, but has already shown that under natural conditions the soil is of the " solenetz " type. This is a term used in the modern system of soil classification for the result of a process that is characterised by two phases—(1) the accumulation on the surface horizon of salts of alkali metals, and (2) a subsequent base-exchange, the calcium from the zeolitic humus complex being replaced by sodium, with the formation of a sodium complex. The soil as a whole acquires a definite and recognisable structure, and the exchanged calcium and other ions are washed down in solution to the lower layers, leading to the accumulation of gypsum in a layer of soil or ' pan ' perceptibly harder than the layers above or below. The characteristics of the natural soil being thus established, it becomes easier to consider the probable consequence of the chemical and physical actions which will result from the change over to irrigation farming, and thus to recommend, with some confidence, practical precautions against deterioration into alkali or water-logged conditions.

Breeding improved and higher yielding varieties.

It is in this direction that perhaps the greatest achievements of agricultural scientists in India have been recorded, and the

opportunities for further advances are still numerous. The greatest part of the work of the Botanical Section is devoted to problems connected with plant-breeding ; the results of breeding for improved quality have been discussed separately with special reference to wheat, barley and tobacco. From the extensive work on numerous crops, in which increase of yield is the main object, the following results may be given as typical.

Barley. Further yield trials have shown the superiority of Type 21. In the Muzaffarpur District, Bihar, it gave about 15 per cent. more than the local varieties, and it was also the heaviest yielder in the trials made by the Deputy Director of Agriculture at Shahjahanpur :—

Pusa varieties	B-4 (Type 21)	2,683 lb. per acre.
	B-23 (Type 20)	1,744 lb. per acre.
	B-22 (Type 12)	1,787 lb. per acre.
Cawnpore varieties	B-255	1,972 lb. per acre.
	B-251	1,882 lb. per acre.

Oats. There is a steadily increasing demand for B. S. 1 and B. S. 2 oat seed owing to their higher yield and better quality as compared with local varieties. The B. S. oats have now been hybridised with Abundance and Scotch Potato varieties, and further improvements in yield and plumpness of grain, and quantity and strength of straw, have been secured, and in the coming season field-scale trials will be made.

Linseed. The primary practical object of this work, begun some years ago, was to improve the oil-content of two local types (12 and 121) which have a high yield, by crossing with Central Indian varieties which have high oil-content but low yields. Strains which appear to be pure for high oil-content and yield have been selected, and the following table compares the oil-contents of the types 12 and 121 with the higher oil-content of high-yielding hybrids.

Table showing the oil-content in linseed hybrids.

Strain	Oil per cent. in			Mean
	1928-29	1929-30	1930-31	
Type 12 and Hybrids.				
T. 12 Parent	36·67	36·93	37·68	37·09
1×12 H 2	40·99	40·47	40·78	40·75
12×1 H 10	43·00	42·20	41·49	42·23
12×1 H 11	43·13	43·25	43·50	43·29
Type 121 and Hybrids.				
T. 121 Parent	40·01	40·13	38·88	39·69
121×11 H 63	44·64	41·52	43·37	43·18

This work has now reached the stage of large-scale field trials.

Gram. Of the numerous new types isolated in the last and previous years, one, T. 58, gave on a field-scale trial about the same yield as T. 17 (*circa* 1,000 lb. per acre) and better results than T. 25 (under 800 lb. per acre). All these three types are yellow-seeded; T. 28, which is white-seeded, yielded nearly 900 lb. per acre in the same trial.

Many other crops are also under investigation, for full details of which and of the numerous points of genetical interest connected with the work, reference should be made to the report of the Botanical Section.

Sugarcane. For climatic reasons, breeding work on canes is done at the sub-station at Coimbatore, Madras, by the Sugarcane Expert and his staff. The improved types of thin or sub-tropical cane developed at Coimbatore are rapidly replacing the local types in the white-sugar area of North India, because of their greater yield and sugar-content. In the year under review the most noticeable changes were the steady replacement of Co. 205 by Co. 285 in the Punjab, in both irrigated and unirrigated areas, and, in the United Provinces, the indication that Co. 290, which is a recent production, will be shortly replaced by even more recent canes with Co. numbers over 300.

The work on thick or tropical canes, which was started more recently, has reached the stage permitting distribution of the first batch of seedlings for trial at provincial stations. The initial difficulties in devising a satisfactory technique for thick-cane breeding are being steadily overcome by careful studies of the scientific factors involved. In particular, attempts are being made to increase the range of possible crosses by controlling the time of flowering, and to prolong the viability of pollen by storage under suitable conditions. Some success with pollen storage has been obtained. Pollen kept in a dry but not air-tight vessel (10 grams of calcium chloride per 1,000 c.c. of space) at a temperature between 8° C. and 13° C. remained uncaked and gave 12 per cent. of germination after 7 days' storage.

Sugarcane×Sorghum hybrids. Much attention has been devoted to this highly interesting and significant cross. Reference was made last year to the practical value of a sugar-giving plant with a shorter growing period than sugarcane, in view of the more efficient use of both the land and the factory that would follow. During the year a number of items of additional evidence have been obtained on the characteristics of the crosses. The shape and size of the inflorescence (*see* Plate II of the Sugarcane Expert's Report), the chromosome number in the pollen mother-cells, the awned fourth-glume, and the colour of the stigmas, are all evidence of the genuine nature of the cross. So also is the fact that all hybrids that flowered showed aborted anthers or sterile pollen. Since the cross-pollinations with other healthy sugarcane pollen suggested

pistil infertility also, there appears little hope of further crossing the hybrids.

A further characteristic of the hybrids is the large number of deaths in the seedling stage, associated with chlorophyll deficiency, mis-shapen stems, and above all from a poor development of early roots. The latter difficulty may possibly be reduced by selecting other sugarcane and sorghum parents. Up to the present only P. O. J. 2725 and *Sorghum Durra* have been employed.

Of those that survive to maturity, a small proportion have the right habit of growth and vigour, and of these a number, which matured in six months, showed encouraging figures for juice analysis. The figures are given in the following table and should be compared with the values for the two parents : P. O. J. 2725, 19 per cent. sucrose after 12 months ; sorghum, 4·5 per cent. after 5 months.

Sugarcane×Sorghum hybrids, mature at 6 months. Juice analysis.

Seedling No.	Brix %	Sucrose %	Glucose %	Co-efficient of purity
Co. 351	20·42	18·53	0·17	90·8
Co. 352	19·31	17·33	0·26	89·6
Co. 353	19·01	16·75	0·42	88·1
Co. 354	18·38	16·18	0·41	88·0
Co. 355	17·71	15·22	0·58	85·9
Co. 356	18·51	16·11	0·50	87·0
Co. 357	20·15	18·00	0·18	89·3

The work on these interesting hybrids is being actively carried on, so that a sufficient quantity of the promising types may be raised to test the ultimate crucial point as to what yield of crude sugar per acre these short-duration plants will give in field conditions.

Prevention and control of plant diseases and insect attacks.

It is not easy to estimate the real money loss caused by plant diseases or injuries, since it must be based on an unverifiable guess of what yield would accrue in the absence of attack. The best judges consider that an average annual loss of 10 per cent. is not an excessive estimate. Translated into money values, this is a very large figure, and if even only a small proportion of the total loss could be avoided, the money gain would amply cover the cost to the country of the agricultural research programme.

Plant diseases. Plant diseases have a variety of origins: the bulk of them are due to the attack of fungi, which become parasitic on the plant; but there are also diseases due to bacteria, and in recent years the ravages of the mysterious and little understood " virus-diseases " have been brought to light and are being investigated in every civilised country. It is satisfactory to record that a considerable extension of our investigations at Pusa on the virus-diseases of sugarcane will now be possible owing to the grant of funds by the Imperial Council of Agricultural Research for the appointment of two specialists.

Diseases due to fungi, which are the special concern of the Mycological Section at Pusa, have been studied for a longer time than bacterial diseases and more is known therefore about control and remedial measures. These measures are of necessity based on a thorough understanding of the habits of the particular fungus causing the disease, and its identification; the working out of its life-history, its mode of attack, its susceptible and resistant periods, if any, calls for skilled and patient investigation. The report of the Mycological Section should be consulted for details of the work, as only typical instances can be given here.

A leaf blight attacked many of the cultures of gram, variety T. 68 being most severely infected. Although laboratory experiments indicated that 0·5 per cent. formalin solution killed the spores and prevented fungal growth, without affecting germination of the gram seed, a field trial of seed so treated was a failure as a large proportion of the seed did not survive treatment. The experiment will be repeated to ascertain whether there is some further condition to be observed to secure successful treatment.

An experiment was also carried out to ascertain the resisting power of various barley varieties bred at Pusa to *H. Sativum* and the effect of treating the seed before sowing. The seeds were heavily infected with the spores of the fungus, by laboratory treatment, before the fungicide was applied to them. It was found, as would be expected, that different varieties behaved differently. Variety T. 17 seems to be more sensitive than the others to infection, and also more responsive to fungicide treatment :—

H. Sativum on Barley : Percentage deaths due to foot- and root-rot.

Type	Sown dry (control)	Seeds soaked in water	Seeds infected	Infected seeds disinfected
T. 21	20·0	19·1	19·7	15·0
T. 17	43·8	48·0	49·1	24·8
T. 12	16·1	14·7	20·6	17·3
T. 7	18·0	16·4	19·2	16·1

An estimate was made of the percentage of leaf area destroyed in the surviving plants with the following results :—

H. Sativum on Barley: Percentage destruction of leaf area in surviving plants.

Type	Seeds sown dry	Seeds soaked in water	Seeds infected	Infected seed disinfected
T. 21	1·4	1·7	1·3	1·3
T. 17	1·3	1·4	1·2	1·1
T. 12	9·9	6·6	9·2	8·1
T. 7	6·6	5·4	6·5	5·1

Comparison of the two tables shows that the more susceptible the variety is to foot- and root-rot, the more resistant are the surviving plants to destruction of the leaf area; this is an interesting inverse relationship which may have some physiological significance.

The attacks of *Phytophthora* sp. on *Piper Betel* have been further investigated, and the efficiency of Bordeaux mixture in controlling the disease has been demonstrated, provided the area is not exposed to heavy flooding.

Rhizoctonia Solani, a soil fungus which attacks the roots of the betel and causes symptoms of wilt, is appearing over a wider area, and work is in hand to ascertain whether a soil disinfectant will check it.

Among the many environmental factors which are concerned in the degree of incidence, and virility of fungus attacks, the climatic conditions are perhaps most important. This is well brought out by the observations on the wheat bunt, *Tilletia indica* n. sp., which was discovered on wheat at Karnal last year. Examination of wheat in the Lahore grain market which draws its supplies from various parts of the Punjab showed that the disease is present throughout the province. Bunted grains from Karnal were taken to Pusa and grown, and a number of infection experiments in plots and in pots, and with seed and seedlings, were made. In no case could infection be produced, owing, probably, to the inability of the fungus to withstand the higher temperatures experienced at Pusa during the wheat-growing season.

Insect attacks. Plant damage due to insect pests is, in general, direct mechanical injury which kills the plant or so weakens its vigour that it becomes liable to secondary infection from fungus or bacterial diseases.

To these must be added the formidable toll of those virus-diseases which are directly transmitted to plants by biting and sucking insects. As with fungus diseases, control measures against insect pests have somewhat limited scope in ordinary agricultural practice, for economic reasons. However in centres where important cash or luxury crops are grown, *e.g.*, planters' estates, and horticultural areas, preventive measures, such as suitable spraying, or the removal of insects, larvae or egg-masses by hand, etc., are often financially possible. A further measure of control which has had some striking successes in recent years, particularly in cases where an insect pest not indigenous to the country has been accidentally introduced and has multiplied exceedingly, is the liberation of parasites or predators on the pest in question. Any method of control, however, depends for its success on previous investigations of the mode of attack of the pest on the plant, the vulnerable periods in its life-history, and of the degree of incidence and seasonal variations of parasites and predators. The Entomological Section is engaged on work in all the above lines, and has paid detailed attention to sugarcane. Examination of canes shows how extensive the damage may be from termites, stem- and root-borers, and top-shoot borers. An examination of 1,000 canes each of Co. 213 and 205 gave the following results :—

Percentages of undamaged and attacked canes.

Variety	Undamaged	Top-shoot Borer	Stem-Borer	Root-Borer	Termites
Co. 213 . .	7·1	73·2	23·5	27·7	66·9
Co. 205 . .	14·1	80·3	8·3	39·0	33·0

The low percentage of sound canes is noteworthy, while of the damaged canes many were attacked by more than one class of insect. Further examination of some 17 Coimbatore varieties before despatch to the mills showed that attack by top-shoot borer (*Scirpophaga nivella*) ranged from 50 per cent. in Co. 223 to 95 per cent. in Co. 301 ; the attacks by stem-borers (*Diatraea venosata*, *Argyria sticticraspis* and *Chilo zonellus*) ranged from 7·7 per cent. in Co. 231 to 15·5 per cent. in Co. 213.

Remedial measures against these pests must be restricted, for economic reasons, to inexpensive methods. In one experiment the effect of immersing the setts for 3 days in water prior to planting was tried with the idea that the borers present in the setts would be killed. The improved growth, compared with that given by setts which were examined for borers before planting, was too slight to offset the trouble and expense of water treatment.

More success was obtained by deeper planting (6″) of the setts, the percentage of affected canes being appreciably less than with shallow planting (3″). The results for two varieties of cane were :—

Co. 303, shallow, 23·0 per cent. ; deep, 19·4 per cent.
Co. 205, ,, 12·2 ,, ,, 9·6 ,,

The favourable result was probably due to the bulk of the earlier egg-laying being done on the shallow-planted canes, which sprouted earlier ; and it remains to be seen whether the same reduction in infestation would occur if all the setts in an extensive area were planted more deeply.

Further experiments on the control of the top-shoot borer by hand collection of the moths and egg-masses have given encouraging results, the areas so examined containing less borers than adjacent ones. The cost of this operation was 4½ annas per acre per month, although the labour was untrained and frequently changed. This figure could be appreciably reduced if the work were done systematically, and is worthy of trial in areas where labour is available.

In the course of these and other experiments parasitised insects and egg-masses were bred out in the Insectory, as a preliminary step in attempts to control the pests by the liberation of their parasites.

Prevention of disease by the employment of immune varieties. Remedial and control measures against plant diseases and pests must obviously be economically possible if they are to be of any practical use ; this restriction severely limits their scope in agriculture, and automatically directs attention to the possibility of avoiding the attacks by using resistant or immune varieties of plants.

Such varieties may already exist or they may appear as sports, or again, they may be the result of patient work by the plant-breeder.

In the course of some investigations on a wilt disease of *rahar* (*Cajanus indicus* Spreng.) the Mycology Section observed that the crop from ordinary commercial or farm seed had differing degrees of resistance to wilt. The work of isolating the resistant strain was carried on for some time and then handed over to the Botanical Section for more detailed study. The wilt-resistant property of Type W. R. is now well established ; a comparison experiment in an infected field showed that the resistant form had under 1 per cent. of deaths against over 74 per cent. in the susceptible Type 1. The progeny of crosses of T. 1 with the two resistant strains W. R. and T. 204 reached the F_2 stage last year. The survivors in the infected plot included one line which bred true for all the characters studied and had absolute immunity. The seed from this has been selected for future work. Both of the established resistant strains, W. R. and T. 204, have a spreading habit of growth ; it remains to be seen whether it is possible to secure a resistant form having the more agriculturally desirable upright or poplar-like habit.

The Spread of Improved Varieties of Crops.

The most direct proof of the value of plant-breeding investigations in the present stage of development of Indian agriculture, is given by the records of the amount of improved seeds, etc., distributed to growers. In the past season the Botanical Section and its new Sub-station at Karnal, with the active co-operation of the Agricultural Section at Pusa, distributed to Provincial Departments of Agriculture and to private growers the following quantities of seed of improved varieties :— 37,953 lb. of wheat, 4,358 lb. of barley, 124,138 lb. of oats, 1,427 lb. of gram, 914 lb. of *rahar*, 1,943 lb. of linseed, 8 lb. of tobacco, 66,748 lb. of sugarcane setts, 3,526 lb. of maize and miscellaneous. When the new Botanical Sub-section Area at Karnal is in full working order, these figures will be appreciably increased. Even as they stand, they are a legitimate source of satisfaction, for they show beyond question that in one important direction the Institute is actively serving the immediate and practical needs of Indian agriculture. It must be further remembered that these figures, large as they are, correspond to only a small portion of the actual area covered by improved varieties bred at Pusa. Much of the harvest from our supplies of seed is sold, in turn, by the growers for seed purposes. Estimates of the total area now covered by improved Pusa varieties indicate that Pusa wheats now cover over 1,000,000 acres, while the Co. canes developed at Coimbatore are fast replacing the local varieties throughout North India.

The Position of Stock and Dairy Farming in Indian Agriculture.

The outstanding feature of Indian agriculture in general is that not only are the cattle not an integral part of the agricultural system, but, in addition, their numbers are largely in excess of all possible requirements even for the inefficient service to which the system condemns them. The country is in a vicious circle : the cattle are not properly bred, or fed, and thus the supplies of manure, which would enrich the soil, and milk, which would bring in a cash income, are both inadequate ; and because of the low fertility of the soil and the impoverishment of the ryot, he is unable to spare enough land to provide a sufficiency of good fodder for his stock. A further difficulty is that the sale of stock for human consumption and for the manufacture of numerous by-products from the offal, which would provide additional income and effect a reduction in the excessive number of cattle, is closed to the bulk of the cultivators for religious reasons. All these facts are of course well known ; the work of the Imperial Dairy Expert and his staff at Bangalore, Karnal, Anand and Wellington, and the Physiological Chemist's Section at Bangalore is aimed at breaking the vicious circle, the Imperial Dairy Expert's Section concentrating mainly, but by no means entirely, on

immediate practical considerations, while the Physiological Chemist's Section pays attention to research problems in the nutrition of cattle, thus serving a complementary *rôle* to the Dairy Section.

There are two important practical measures for improving the position of Indian cattle in the agricultural system, that have received the full attention of the Dairy Section for some years past. The first is to develop by every possible means the supply of milk, and dairy products, to the large centres of population, thus providing rural areas with a steady market for the milk they produce, and encouraging them to improve the efficiency of their milch cattle. The second, and closely allied, measure is to secure this enhanced milk production level of the Indian cow without affecting the efficiency and stamina of the male progeny used for draught purposes.

The Creamery at Anand has examined a number of problems connected with the supply of milk to cities. The semi-churning of milk carried in non-refrigerated waggons to Bombay, and the consequent formation of butter globules on the surface, is a frequent difficulty; the use of an atomising machine to homogenise the milk is now under trial. The prevalent idea that butter made from pasteurised cream of buffalo milk has poorer consistency and a lower melting point than that made from unpasteurised cream was also tested, and the idea was shown to be without real foundation.

The question whether the male progeny of good-milking dams deteriorate for draught purposes constitutes the major problem under investigation at the Karnal farm. Two herds of cattle, Thar Parkar and Hariana, and buffaloes have been carefully bred for milk production for some years past and a steady improvement has been secured :—

Year	Thar Parkar	Hariana	Buffaloes	Remarks
	lb.	lb.	lb.	
1927-28 . . .	1,965	1,905	8,278	Few cattle.
1928-29 . . .	1,800	1,950	3,600	
1929-30 . . .	2,426	2,329	3,763	
1930-31 . . .	2,805	2,464	4,398	

This experiment has now reached the stage of testing the draught capacity of the male stock; 16 calves of both breeds have been selected from heavy milkers, and will be reared and treated in the same way as the remainder. They will all be castrated when 18 months old, and in due course compared for draught. This experiment is a crucial one for the future of Indian agriculture, and the results are awaited with great

interest. If it can be shown that, by careful breeding and adequate feeding, high milking cows as well as sturdy bullocks can be obtained, there will be a definite incentive to the farming community to grade up their own stock. They will need expert advice on the best methods, and the information on which this advice must be based is being steadily accumulated in the Dairy Section ; for example, the relations between milk yields, live weights, and age, and the effect of seasonal calving on milk yield, can be ascertained with some precision from an examination, over a series of years, of the farm-records.

It is evident that improved cattle cannot be maintained unless the standard of feeding is raised; the researches of the Physiological Chemist's Section on nutrition factors in the growing animal are providing valuable information on the most suitable rations, the feeding values of coarse fodders and grasses, and on the physiological behaviour of the animal.

During a feeding trial with heifers in which *ragi* (*Eleusine coracana*) straw and hay were compared it was noted that a much greater weight of hay was consumed ; while the greater palatability of the hay was no doubt concerned, it was found by laboratory work that *ragi* straw swells very much when wetted, and hence its consumption was limited by the swelling after ingestion.

The effect of silage on milk production was tested by feeding one group of cows in milk with as much as they could eat (about 30 lb. fresh silage daily) while the second group had a more limited amount (17 lb. per day). *Ragi* straw *ad lib.* was given to both groups and concentrates in proportion to yield. It was found that milk yield was slightly greater with the ration containing less silage, the animals eating more *ragi* straw to make up the shortage ; this is an important point, as silage is both expensive to make and to feed. It is of interest to note that although a greater milk yield was secured, the live-weight increase of this group was appreciably less than that of the other ; it is hoped to follow this point up in more detail later. A further point of some significance is that the milk was produced at a very economical rate of food consumption, which is possibly due to chaffing all the fodder ; this is also being further investigated.

Under present conditions of stock management, coarse fodders are of great importance and the nutritive value of those in use (and other possible ones) is receiving attention. Experiments have already shown that the digestibility of the carbohydrates is at times much below normal. Additional and more varied samples are now being examined from the areas in question, and the constituents of the grasses are being analysed to ascertain the causes of the depression.

The study of silage and silage-making continues. Cereal straws are under test, with the main idea of providing succulent and tasty foods during dry weather. This year rice straw was used and an excellent

silage was produced, which was much relished by the stock. Green *jowar* (sorghum) has also been used, and different methods of filling the pit or silo have been studied ; slow filling and moderate watering produced the largest quantity of good silage from a given bulk of fresh material.

Recent work on nutrition has stressed the importance of the mineral constituents of the ration on the growth and health of the animals. Various deficiency diseases have been recorded in different parts of the world, caused by the absence or paucity of certain mineral ingredients, *e.g.*, phosphorus, calcium, iron, iodine, which are in any case needed only in relatively small quantities. One experiment in feeding a small dose of iodine to calves showed that the digestive system was strengthened ; one animal only had a slight attack of indigestion, whereas in the control group seven had intestinal troubles followed in two cases by death.

In addition to the researches selected for discussion above, other valuable investigations are in hand, for which reference should be made to the full reports of the Dairy and Physiological Chemistry Sections.

Propaganda, training of students and supply of information. The preceding pages have stressed the backward state of all forms of animal husbandry in India. While research is essential for solving many urgent problems and as an insurance against disastrous mistakes in the future, there exists an immediate necessity for active propaganda in favour of known methods of improvement in animal husbandry and in all phases of the dairy and dairy products industry in India. This work, and the training of students wishing to enter the business, falls predominantly on the Imperial Dairy Expert and his staff, and it is evident from a perusal of the present and past reports of that Section that such advice and training constitute two of the most important and indispensable portions of its activities for the betterment of Indian agriculture.

II. GENERAL ADMINISTRATION.

Charge. Dr. W. H. Harrison officiated as Director until November 5th, 1930, when Dr. B. A. Keen took over charge. The post of Joint Director was held by Dr. Shaw up to November 5th, 1930, by Dr. Harrison from November 6th to March 6th, 1931, and by Dr. W. McRae from March 7th, 1931.

Staff. Owing to absences on leave, etc., the following temporary changes in the charge of the various Sections were made :—

Botanical Section. Khan Sahib Abdur Rahman Khan from March 19th, 1931, *vice* Dr. Shaw on leave.

Chemistry Section. Dr. J. Sen to November 5th, 1930 ; Dr. W. H. Harrison from November 6th, 1930, to March 6th, 1931 ; Dr. B. A. Keen from March 7th, 1931.

Bacteriological Section. Mr. N. V. Joshi from April 7th, 1931, *vice* Mr. J. H. Walton on leave.

Mycological Section. Dr. M. Mitra, *vice* Dr. W. McRae on leave, till December 6th, 1930.

Entomological Section. Mr. P. V. Isaac, *vice* Mr. T. Bainbrigge Fletcher on leave, till October 25th, 1930.

Agricultural Section. Mr. Arjun Singh from March 17th, 1931, *vice* Mr. Wynne Sayer (Officiating Imperial Agriculturist).

Sugar Bureau Secretary. Rao Sahib Kasanji D. Naik, *vice* Mr. Wynne Sayer, from March 18th to March 31st, 1931, when the Sugar Bureau and the Sugar Cable Service were transferred to the Cawnpore office of the Sugar Technologist to the Imperial Council of Agricultural Research.

The Library. The number of publications received in exchange was 3,570, while 1,050 were purchased. Books issued on loan to scientific workers in the provinces numbered 544, as compared with 352 for the previous year; it is evident that the resources of the Pusa library are being increasingly appreciated by workers throughout India. Unfortunately, the cessation of certain purchases and exchanges from time to time in the past have resulted in numerous deficiencies. In particular, the runs of many important foreign journals and bulletin series are broken, and the value of the library for consultation is seriously impaired. During the year energetic steps have been taken to obtain as many of the missing publications as are still available. Thanks are due to the Smithsonian Institution, Washington, U. S. A., for obtaining, free of charge to us, a considerable number of the missing American bulletins; while from a private source a donation of some 750 reprints, etc., has been received.

Post-graduate and Diploma students. Five post-graduate workers completed their two years' work at Pusa, three in Botany and one each in Mycology and Chemistry, and two Provincial Assistants completed the special one-year course in practical agriculture.

There were 30 applicants from post-graduates for the session beginning November 1st, 1930; seven were selected for interview, of whom two were admitted, one in Botany and one in Mycology. Two other students were accepted for training in Botany, and one from the Indore Durbar for training in Chemistry. One Provincial Assistant, and one deputed by the Jaipur Durbar, joined the practical agriculture course.

Five post-graduate workers in dairying completed the 15 months' course, and three joined for the new session. The two-year course for the Indian Dairy Diploma was completed by 24 students; as this year was the intervening year no admissions were made.

A number of students and post-graduate workers was also admitted for shorter periods of work, or training, in various Sections of the Institute.

Extensions. Grants from the Imperial Council of Agricultural Research have enabled much needed extensions of the work of certain Sections to be put in hand. The Botanical Section, and the Sugarcane Breeding Station at Coimbatore, have been provided with land and buildings for Sub-stations at Karnal, which will be of the greatest help in supplying the large demands from Northern India for strains of the improved varieties produced by the Institute. The Mycological Section has also been provided with funds for a series of investigations on the virus-diseases of sugarcane.

Buildings and Works. The electrical, gas, water, and ice supplies, on which the Institute, owing to its isolated situation, is so greatly dependent for its efficiency, have been skilfully maintained. One class II service officer's quarter has been under construction ; the shortage of quarters for the class II officers, the clerical staff and menials is, however, still acute.

Hospital. There were 298 in-patients and 7,045 out-patients in 1930, and 1,306 operations were performed, 18 being "selected" ones. The more important diseases were malaria (380), cholera (369), kala-azar (212), dysentery (139), leprosy (2).

The health of residents of the estate was satisfactory. There was an epidemic of cholera in March-May 1930 in the neighbouring villages, but, by suitable measures instituted by the Medical Officer, the estate residents were kept practically free from the disease.

III. ACCOUNTS.

The total expenditure for the Institute and its Sub-stations during the financial year ending 31st March, 1931, was Rs. 14,64,949* as against Rs. 15,14,974 for the previous year :—

	Rs.
Pusa Institute—	
General expenditure of the Institute, including the Office of the Director with the medical and estate establishments	2,76,378
Chemical Section	71,530
Mycological Section	33,693
Entomological Section	68,457
Bacteriological Section	56,579
Botanical Section	62,718
Agricultural Section	1,32,910
Sugar Bureau	31,770
Cable Service	20,020
Sub-stations—	
Imperial Dairy Expert, Bangalore	51,334
Bangalore Dairy	1,51,558
Wellington Dairy	1,24,902
Anand Creamery	1,07,666
Karnal Cattle Breeding Farm	1,38,700
Physiological Chemist, Bangalore	59,898
Sugarcane Station, Coimbatore	76,836
TOTAL	14,64,949

* Provisional figure.

The receipts amounted to Rs. 4,70,756* as shown below :—

	Sale of dairy produce and live-stock	Sale of farm produce	Fees from students	Miscel-laneous receipts	Total
	Rs.	Rs.	Rs.	Rs.	Rs.
Pusa Institute . .	31,864	18,345	3,550	22,298†	76,057
Bangalore Dairy . .	1,16,550	442	2,440	8,288	1,27,720
Wellington Dairy . .	77,945	708	485	3,342	82,480
Anand Creamery . .	80,214	..	1,648	13,887	95,749
Karnal Cattle Breeding Farm.	30,900	42,207	955	3,727	77,789
Sugarcane Station, Coimbatore.	..	..	..	10,961	10,961
TOTAL .	3,37,473	61,702	9,078	62,503	4,70,756

* Provisional figure.

† Includes Rs. 11,219 received as subscriptions to the Sugar Cable Service.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(Khan Sahib Abdur Rahman Khan, in charge.)

I. INTRODUCTION.

Dr. Shaw held charge of the Section up to 18th March, 1931, when he proceeded on leave for seven months and Khan Sahib Abdur Rahman Khan, First Assistant, assumed charge of the Section. The sum of approximately Rs. 1,576 was realized mainly from the sale of improved seeds and credited to the Government during the year under report. The establishment of a Botanical Sub-Station at Karnal, for five years in the first instance, was sanctioned by the Government of India in September, 1930. A separate report on this Station has already been submitted.

Training.

Messrs. P. D. Dixit, M.Sc., R. B. Ekbote, L. Ag., and R. M. Madhava Row, B.A., completed their post-graduate training in this Section in October, 1930. Mr. P. D. Dixit, however, was permitted to continue his studies as an honorary research worker up to 1931 and has investigated the cytology of the chilli and gram plants. Mr. R. B. Ekbote was awarded the Woodhouse Memorial Prize (1929) for his essay on " The value of hybridization in the improvement of crops ". Mr. K. L. Khanna, B.Sc., worked in this Section from 30th June, 1930, to 30th October, 1930.

Messrs. M. B. V. Narasingha Rao, B.A., B.Sc., T. R. Mehta, B.Sc., and A. R. Akhtar, M.Sc., continued their post-graduate course during the year under report and were of material assistance in the different problems to which each of them was attached. Mr. T. R. Mehta was also awarded the Woodhouse Memorial Prize (1930) for his essay on " Breeding of disease-resistant crops ".

Messrs. Basudeva Rao, L. Ag., Parlakimedi scholarship-holder, R. G. Joglekar, B. Ag., King Edward Memorial (C. P.) scholarship-holder, and D. C. Agarwala, L. Ag., United Provinces Department of Agriculture scholarship-holder, were admitted this year for the full post-graduate course of instruction.

Two students from the Punjab were permitted to devote some time to a detailed study of gram types.

Season and rainfall.

The rains were deficient in the early part of the monsoon and the total annual rainfall remained below the average for the last 25 years by 11·92 inches. The cloudy weather and rains in February and March aggravated the attack of rust in wheat.

Statement of rainfall in Botanical Section in 1930-31.

Month	Average for 25 years 1906-1930	From 1st June, 1930, to 31st May, 1931	Difference
June	7·53	5·94	—1·59
July	11·08	6·20	—4·88
August	14·09	5·08	—9·01
September	8·05	12·64	4·59
October	1·81	1·74	—0·07
November	0·43	0·45	0·02
December	0·18	0·50	0·32
January	0·34	0·06	—0·28
February	0·68	0·84	0·16
March	0·41	0·25	0·16
April	0·56	0·00	—0·56
May	1·44	0·98	—0·46
TOTAL	46·60	34·68	—11·92

SEED DISTRIBUTION OF IMPROVED VARIETIES OF CROPS.

As previously reported, the area under the Botanical Section is not sufficient for the seed multiplication of pure and improved varieties of crops. Most of this work was carried out on the Pusa Farm with the collaboration of the Imperial Agriculturist. Some crops were also grown at the Botanical Sub-Station, Karnal, for the same purpose. The demand for wheat and barley seeds was much more than it was possible to supply. The approximate quantities of different improved seeds distributed to Departments of Agriculture and private growers during the year under report are shown in the following statement :—

Statement showing the seed distribution of improved crops evolved in the Botanical Section, Pusa.

Crop	Variety	By the Botanical Section, Pusa	By the Pusa Farm	By Karnal Botanical Sub-Station	Total
		lb.	lb.	lb.	lb.
Wheat	P. 4	98	6,088	..	6,186
	P. 12	64	2,808	..	2,872
	P. 52	595	22,058	4,746	27,399

Statement showing the seed distribution of improved crops evolved in the Botanical Section, Pusa—contd.

Crop	Variety	By the Botanical Section, Pusa	By the Pusa Farm	By Karnal Botanical Sub-Station	Total
		lb.	lb.	lb.	lb.
Wheat—(contd.)	P. 80-5 .	211	..	..	211
	P. 111 .	1,036	..	..	1,036
	P. 112 .	184	..	..	184
	P. 113 .	87	..	..	87
	P. 114 .	431	..	20	451
	P. 163 .	59	..	..	59
Barley . . .	T. 21 .	93	4,182	..	4,275
	T. 20 .	83	..	..	83
Oats . . .	B. S. 1 .	..	45,510	..	45,510
	B. S. 2 .	2,204	..	..	2,204
	Hybrid A .	902	..	..	902
Gram . . .	T. 17 .	604	328	..	932
	T. 25 .	297	..	..	297
	T. 28 .	198	..	..	198
Rahar . . .	T. A. .	164	..	..	164
	T. B. .	..	82	..	82
	T. E. .	299	..	..	299
	T. S. .	82	..	..	82
	T. T. .	82	..	..	82
	A. 2 .	205	..	..	205
Linseed . . .	T. 12 .	378	..	..	378
	T. 121 .	1,216	..	..	1,216
	T. 124 .	349	..	..	349
Tobacco . . .	T. 28 .	3	..	..	3
	Hybrid 177	5	..	..	5

II. INVESTIGATION.

WHEAT (*Triticum vulgare*, L.).

(*a*) *Breeding.* About 110 single plant cultures of P. 4 × Federation and P. 52 × Federation F_6 were grown and studied. Some cultures of the above crosses were also grown on a field scale, out of which two, P. 163 (P. 4 × Federation) and P. 115 (P. 52 × Federation), proved to be the best and were selected for further trials. The weather conditions in the year under report were exceptionally favourable for rusts on wheats, and this afforded a good opportunity for the study of rust-resisting qualities of the various cultures under study. It is interesting to note that at Pusa orange rust (*P. triticina*) was the most serious of the rust diseases and that our selected varieties were generally resistant to this rust. At Karnal, however, yellow rust (*P. glumarum*) was the most serious rust disease in the year under report and both Pusa 52 and Pusa 115 were badly attacked by it although neither of these wheats was badly rusted in Pusa.

(*b*) *Milling and baking tests.* (i) With the object of investigating the quality of some Pusa wheats grown at Pusa under dry conditions, and at Mirpurkhas under irrigation conditions, and to compare them with some Sind wheats, the following 16 samples were sent to England for milling and baking tests :—

No. of sample	Name of wheat	REMARKS
Pusa set . . .	1. Pusa 4 . . .	Grown at Pusa under dry conditions.
	2. „ 12 . . .	Ditto.
	3. „ 52 . . .	Ditto.
	4. „ 80-5 . .	Ditto.
	5. „ 111 . . .	Ditto.
	6. „ 114 . . .	Ditto.
Sind set . . .	7. Pusa 4 . . .	Grown under irrigation at Mirpurkhas.
	8. „ 12 . . .	Ditto.
	9. „ 52 . . .	Ditto.
	10. „ 80-5 . .	Ditto.
	11. „ 111 . . .	Ditto.
	12. „ 114 . . .	Ditto.
	13. C. P. H. 47 . .	Ditto.
	14. A. T. 38 . .	Ditto.
	15. G. S. 25 . .	Ditto.
	16. Choice White Karachi (C. W. K.)	....

These tests were carried out by the Research Association of British Flour-Millers and a report on the results obtained was published in full as an appendix to an article "Milling and Baking Tests with some Indian wheats grown at Pusa and at Mirpurkhas (Sind)" in the *Indian Journal of Agricultural Science* I, 1931, pp. 395-414. The summary of the report is reproduced below :—

"Wide variations in type and quality have been encountered amongst the sixteen samples—so much so, that the extremes almost might be said to typify 'Strength' and 'Weakness'.

On the whole, the Pusa samples appeared of much higher quality than the Sind though it is perhaps not justifiable to make a clean-cut division.

Certainly the finest samples were amongst the Pusa set, and of these No. 5 (P. 111) was outstanding. It appeared to be equivalent in value to a good Manitoba wheat, and we have no hesitation in saying that if No. 5 (P. 111) can be successfully grown in India it should be of commercial importance as a strong wheat. It was most attractive in appearance although quite unlike Manitoba, its bright amber colour being in sharp contrast to the typical Manitoba red. It was of excellent milling quality. It appeared to offer no difficulties as regards conditioning treatment and it seemed distinctly easier to mill than most customary hard wheats. It gave a high yield of flour which was of good appearance (of the hard wheat flour type), and had a remarkably low ash content and high protein content. Like many hard wheat flours it was not a good gasser.

In the bakehouse it gave a dough of excellent handling qualities, with the wide fermentation tolerance of a strong flour, and excellent bread. It appeared to have the blending value of a strong flour.

No. 4 (P. 80-5) was nearly as good, generally, as No. 5 (P. 111). Next in order of merit but a long way behind came No. 1 (P. 4).

A wheat of a weaker type may on account of certain qualities be of just as much commercial importance as a strong wheat. In this connection certain of the Sind samples appear to deserve mention. As relatively weak wheats, Nos. 8 (P. 12 Sind) and 12 (P. 114 Sind) appeared to have high blending value. They milled well as relatively soft wheats, and gave good white flours. No. 8 (P. 12 Sind) had a normal protein content for soft flours but 12 (114 Sind) had had comparatively high protein content. It is true that they were not good gassers, and they had the restricted fermentation tolerance of weak flours, but they gave dough of good handling qualities, from the blending point of view, and they appeared to fine advantage in the bread. From all points of view these were superior to ordinary Karachi wheat as commercially used for blending in this country.

Many of the remaining samples may be said to fall between two stools in the sense that they possess neither the degree of strength of the best Pusa samples, nor the value of weakness for blending purposes of the best Sind samples.

The poorest samples are fairly definitely Nos. 13 (C. P. H. 47), 14 (A. T. 38) and 16 (C. W. K.) which are certainly of no more value than ordinary commercial Karachi wheat.

Any further attempt to rank the samples in order of merit must be tentatively made and then in connection with the Sind samples alone. Nos. 12 (P. 114 Sind) and 8 (P. 12 Sind) are best left apart for reasons discussed.

The order of merit of the remaining Sind samples might be as follows :—

Nos. 10 (P. 80-5 Sind), 7 (P. 4 Sind), 11 (P. 111 Sind), 15 (G. S. 25), 9 (P. 52 Sind), 16 (C. W. K.), 13 (C. P. H. 47) and 14 (A. T. 38). Nos. 13 (C. P. H. 47) and 14 (A. T. 38) are distinctly poorest; perhaps a fairly sharp dividing line might be drawn between Nos. 9 (P. 52 Sind) and 16 (C. W. K.)"

(ii) It may be added that Pusa 4 wheat has proved the best in all round merit in the North-West Frontier Province. Samples of this

variety from Tarnab gained the first place in the Milling and Baking Tests of World Wheats carried out in 1927-28 by the United States Department of Agriculture, Washington.

(*c*) *Bushel weights.* The bushel weights of the different varieties of wheats grown at the Botanical Section, Pusa, are kept since 1925-26. The following statement shows the results :—

Wheat	Weight per bushel in lb.					
	1925-26	1926-27	1927-28	1928-29	1929-30	1930-31
Pusa 4 . .	64·9	63·0	63·25	[63·9	65·07	60·8
„ 12 . .	61·5	65·0	56·3	[63·3	62·0	60·0
„ 52 . .	65·5	63·0	62·17	[64·0	65·4	63·6
					63·5	
„ 80-5 .	65·0	56·5	55·9	65·3	63·1	64·9
„ 111 . .	..	..	..	..	66·0	60·3
„ 112 . .	..	..	..	..	61·5	..
„ 114 . .	..	..	..	..	60·0	..
„ 115 . .	..	..	..	..	..	62·8
„ 163 . .	..	..	..	..	..	63·3
„ 6 . .	..	..	..	..	..	63·5
„ 101 . .	..	..	..	..	..	65·4

Barley (*Hordeum vulgare*, L.).

The work on the classification of barley types isolated in this Section and on the root-system of most of these types has been embodied in two papers which have been published in the first number of the *Indian Journal of Agricultural Science.* A paper entitled " Further yield trials with some Pusa barleys ", embodying the results obtained in 1929-30, was also published in the *Agricultural Journal of India.* Some new forms of 2-rowed and hooded barleys were imported from America and appear promising, although almost all of them have suffered much from rust attack. Another yield trial with the four best yielding types was again run this year, and the strip as well as the latin square methods were employed. The results obtained confirm the conclusions arrived at in the previous years and show that Type 21 maintains its position as the highest yielder.

The attack of *Helminthosporium* on barley appears to be increasing in virulence year after year, and it was observed that two species of this fungus, *viz.*, *H. Sativum* and *H. teres*, were present in varying degrees in different barley types. An experiment was started this year, in

collaboration with the 1st Assistant to the Imperial Mycologist, to observe the efficacy of seed treatment in combating this disease, and the results so far obtained are given in the Report of the Mycology Section.

Some seed of Type 21 was distributed this year, and promising reports about its yielding capacity have been received. The Deputy Director of Agriculture, Muzaffarpur, for instance, reports that this type has yielded about 15 per cent. more than the local varieties.

A yield trial run by the Deputy Director of Agriculture, Shahjahanpur, during the current year with Pusa and Cawnpore barleys, has shown the following yields per acre :—

	lb. per acre
Pusa varieties—	
B—4 (Type 21)	2,683
B—23 („ 20)	1,744
B—22 („ 12)	1,787
Cawnpore varieties—	
B—255	1,972
B—251	1,882

A preliminary estimation of the malting value of six types of barley was made in the Chemical Section, and the results are given in the table. Variety T. 20 shows a high degree of diastatic activity.

Report on the composition of malt from six different varieties of barley.

Variety of barley	T. 7	T. 12	T. 20	T. 21	T. 24	B 825 Plumage Archer
Extract per standard quarter, Brewer's pounds.	8·45	8·54	8·42	8·10	8·81	8·36
Moisture per cent. Brewer's pounds	5·52	5·97	5·78	5·73	5·61	6·48
Diastatic activity (Lintner value)	55·56	62·50	83·33	55·56	76·92	76·92
Tint (10 per cent. Wort 1″ cell)—						
Yellow	1°·9	2°·1	2°·4	1°·7	3°·50	3°·8
Red	0°·8	1°·0	0°·9	0°·75	1°·70	3°·6
Cold water extract per cent.	26·43	31·61	35·23	27·98	32·38	39·90

Oats (*Avena sterilis*, L.).

The demand for B. S. 1 and B. S. 2 oat seed is steadily increasing, and very favourable reports on the quality and yielding power of these oats have been received from many Bihar planters and others who have tried these. Some better strains evolved by hybridization of these B. S. oats with the Scotch Potato and the Abundance varieties respectively show definite improvement in the plumpness and yield of grain and the profuse quantity and strength of their straw. The Superintendent of the Imperial Institute of Animal Husbandry and Dairying, Wellington, reports that " the crop of oats from Hybrid A and Hy-

brid B did very well indeed here, much better than B. S. 1 and 2. There was no smut disease at all. .....". All these hybrids will be tried on a field scale in the ensuing season.

The study of the inheritance of some characters is being continued and the F_2 generation of a cross between the wild oat (*Avena fatua*, L.) and B. S. 1 (*A. sterilis*, L.) has afforded an interesting study. The results obtained in the original crosses between the Scotch Potato and Pusa oats which have reached the F_5 stage and between Abundance and a Pusa oat which is in the F_4 generation this year, are being written up for publication.

Linseed (*Linum usitatissimum*, Linn.).

The various pure types were maintained. Thirty-two different types of linseeds and flaxes were received from the Glen Innes Experimental Farm, New South Wales, Australia, and grown, many of which showed splitting for habit, maturity and colour in floral organs, etc.

The sixth generation of the hybrids from the first set of original crosses was grown and the work of selection continued. The genetic results of these hybrids were published in a paper entitled "The inheritance of characters in linseed" in the *Indian Journal of Agricultural Science*, I, 1931, 1-57.

The F_4 generation of the second set of crosses was also grown. Most of the cultures bred true in F_4.

The third set of crosses made last year was also grown, and the F_1 generation throws light on some very important points. For instance, Type 15, which has white petals, when crossed with Types 21 and 24, both of which have pale blue petals, behaved differently. In the first case the F_1 had white petals, while in the other it had blue. This shows that Type 15 has a factor which inhibits pale blue colour in Type 21 and intensifies it in Type 24. From the above it is evident that there are two kinds of genetically different pale blue colours in the petals of the linseeds—a fact which was not recognized up to this time. This will also solve some difficulties with our previous crosses which cannot be easily explained here and will form material for a further paper on the "Inheritance of characters in Indian linseeds".

Gram (*Cicer arietinum*, Linn.).

The isolation of new types was completed last year and a Memoir describing 84 types (59 new and 25 old) was published in the year under report. The F_1 of 4 different crosses made by Mr. A. R. Akhtar, M.Sc., were studied with the following results. In the cross between Type 82 and Type 1, single flower per pedicel was found dominant over double flower condition. The cross between white-flowered Type 11 and blue-flowered Type 13 produced blue flowers, while the cross between another white-flowered Type 9 and Type 13 produced pink flowers. This brings out two points :—(i) That the general constitution of white flower is not the same in all the white-flowered types, (ii) that the pink

colour in the flower results from the interaction of two factors, one of which produces blue colour and the other modifies this blue to pink.

Types 17, 25 and 58 yellow-seeded grams and 28 white-seeded Type were grown on field scale in the Agricultural Farm, Pusa. The new Type 58 compares favourably with Type 17 and has given better results than Type 25. The actual yields are shown in the outturn statement appended at the end of the report.

Peas (*Pisum sativum*, Linn., and *Pisum arvense*, Linn.).

Observations on the isolated unit species were carried on and the tentative classification of these was revised.

Lentils (*Ervum lens*, Linn.).

The original three crosses were carried on to the F_4 generation, while a number of new crosses were studied in the F_2 generation. A preliminary yield trial with the strip method was conducted during the year and showed the superior yielding power of Type 11 over Types 2, 19 and 59. It may be noted that the seed of Type 11 is intermediate in size, while the other three types have large bold seed.

Tara Mira (*Eruca sativa*, L.).

During the last two years this crop has been studied in the Botanical Section. The species is practically self-sterile. Most of the plants do not set seed under bag although pollination does take place. A few plants, however, are slightly compatible and form a small number of pods under bag. Therefore this species provides a good material for the study of the sterility problem. Many experiments were tried and the results obtained so far are summarised below :—

(1) Some plants form more than 50 per cent. of fruits when their flowers are selfed in the bud stage, and sterility in such cases seems to be due to the lack of quick growth of the pollen tubes.

(2) Some plants do not set seed at all even after artificial crossing. In such cases sterility appears to lie in the female organs.

(3) The more homozygous the plants are, the more they develop sterility, especially in their female organs.

In 1929-30 eight plants, Nos. A, B, C, D, E, F, G and H, were selected in four pairs and crossed *inter-se* as shown below :—

1. A × B
2. B × A } 1st pedigree.

3. C × D
4. D × C } 2nd pedigree.

5. E × F
6. F × E } 3rd pedigree.

7. G × H
8. H × G } 4th pedigree.

Thus we got four different pedigrees or eight strains which were again sown in 1930-31.

Each pair of strains was crossed *inter-se*. The plants so far are healthy and are setting seed. It is also interesting to note that as the original plants of each pair were somewhat similar looking the pedigrees are becoming homozygous and look like four different types. Further work will show whether sterility will appear in these strains.

Brassica species.

A number of samples of these species were collected from all over India in 1929-30 for investigation and isolation of types. The information regarding the scientific and vernacular names of these species in the Indian works on Botany is very confusing. The best available record is found in Prain's valuable article, "Mustards cultivated in Bengal", published in the *Agricultural Ledger* No. 1 of 1898, which of course deals with only one province.

A tentative classification of the species and sub-species has been made. All the samples have been grouped into nine species, out of which only three are self-fertile. The work of isolation of types has been taken up in these species and will be completed soon. The remaining six species, which are self-sterile, form a good material for investigation of sterility problem, and various experiments in this direction are in progress.

Safflower (*Carthamus tinctorius*, L.).

All the 34 types were maintained.

The selfed seeds of a variegated (green and yellow) plant, noticed in 1929-30 among the plants grown from unbagged seeds of T. 27, were sown, and the progeny was found to consist of normal and variegated plants in the proportion of 1 : 2.

A number of plants from each of the two types have been bagged with a view to studying their genetical constitution.

Tobacco.

Breeding. With the object of improving the quality of an indigenous tobacco to suit cigarette manufacture a local Type 28 was crossed with an American Adcock in the year 1924. This has resulted in evolving ten hybrids which have now become fixed in their characters and are breeding pure within narrow limits like the original parents. The work is now being published in the *Indian Journal of Agricultural Science.*

The work on the isolation of the important indigenous types of *N. tabacum*, L., has now been completed and this will be published later.

Sterility in Type 56. It was found in a preliminary examination last season that the pollen of this type germinates under lower temperatures. To obtain more information on this aspect, the type was

sown at different dates to flower at periods with different weather conditions. Counts of setting, etc., are being made.

F_2 population. An F_2 population of a cross between a white-flowered tall type and a red-flowered short one was studied for flower-colour, leaf-size, and height. The pheno-type numbers indicated practically a 3 : 1 ratio of pink : white corolla colour, with a number of shades in the pink colour. The height showed a quantitative mode of inheritance. The tabulation of the results of size of leaf is in progress.

Tobacco growing in the rains. Attempts have been made to grow tobacco in Bihar in the rains, sowing and transplanting being done about three months earlier than normal. While the scale on which this has been tried is so far limited, the experience gained indicates that the incidences of leaf spot and leaf curl diseases are likely to prove the limiting factors for the cultivation of tobacco in the rains in Bihar.

Curing. Hybrids 142, 164 and one of the indigenous types (Type 49) were grown and flue-cured. Hybrid 142 yellowed very quickly in the barn and also gave a percentage of yellow leaves which was much higher than in the case of other hybrids hitherto tried. Hybrid 164 also cured fairly well but it was lower in quality and yield to Hybrid 142. Type 49 could not be cured to a bright yellow colour, and this further confirms that none of the indigenous types are much good for flue-curing.

Sesamum (*Sesamum indicum*, DC.).

The F_2 population of a cross between two types of sesamum (Type 3 and Type 29) was studied with reference to their differentiating pairs of characters. The qualitative ones are :—

1. Colour of lower lobe . .	Light purple and purple.
2. Habit of growth . . .	Erect and bushy.
3. Flowers in axil . . .	One and three.
4. Colour of seed . . .	White and black.

Taken singly, erect habit, multiple flower in the axil and white seed behaved as simple Mendelian recessives to their respective allelomorphs giving a typical 3 : 1 ratio. There was, however, a gradation in the intensity of black in the colour of seed, and of whites : non-whites (black of all shades added together) gave a 1 : 3 ratio.

The segregation of colour in the lower lobe of the corolla was on the basis of 9 light purple : 7 purple indicating a difference of two pairs of factors.

When the characters were taken by pairs, *e.g.*, habit and flower in the axil, habit and lower lobe colour, habit and colour of seed, flowers in axil and colour of seed, it was found that the characters showed independent segregation, the observed and the expected giving a fairly good fit in each case.

Maturity, size of flower and capsule showed quantitative inheritance.

For growing the F_3 sufficient numbers of different phenotypes were taken.

Some observations on the growth of *Sesamum indicum* in different soil conditions with special reference to root development were made, and these are being published separately.

Rahar (*Cajanus indicus*, Spreng.).

The observations on the unit species isolated in this crop were carried on and a tentative classification was made. The F_3 generations of WR × 1, 204 × 1, and 172 × 1 from selected F_2 plants were studied in a non-infected area. The interpretations of last year were confirmed except in the inheritance of seed-colour which is found to work on a dihybrid basis instead of monohybrid as reported last year.

Eight good yielding types, four erect growing (types A, B, E & H) and 4 spreaders (G, S, T and WR), were grown on field scale on the Agricultural Farm, Pusa, and in the Botanical Area ; their respective yields are shown in the outturn statement. Types B and T have shown good results this year. The seed of WR type is now available in large quantity for testing. Seed of some plants that were also found to be wilt-resistant last year among the unit species was multiplied and will be tried next year in comparison with the established WR type.

Sterility in rahar. It is sometimes observed that a part or whole of *rahar* plant is devoid of pods and appears sterile. A preliminary study of this sterility was made in all the unit species grown on a small scale and also in types A, B, E, G, S and T grown here on a large scale. The investigation will be carried on next year.

Rahar-wilt experiment. The wilt-resistant property of type WR has been thoroughly established. During the year under review, 209 WR plants were sown in an infected field, in lines alternating with Type 1 lines which had a population of 199 plants. The former showed 0·9 per cent. deaths due to wilt, while the latter which is very susceptible to this disease had 74·3 per cent. deaths under similar conditions.

The F_3 of WR × T. 1 and T. 204 × T. 1 from F_2 plants which survived in the infected plot last year were studied and showed various combinations of characters and various degrees of resistance. One line in particular bred true for all characters studied and showed cent per cent. resistance. Seed of some selected plants from this and from some other promising phenotypes has been selfed and will form the basis for future work. An attempt will be made to secure a resistant strain of *rahar* with an erect habit of branching. It may be noted that the two strains already evolved, *viz.*, WR and Type 204, have an open, spreading habit.

Maize (*Zea Mays*, L.).

The study of selfed lines and further inbreeding work was continued.

Paddy (*Oryza sativa*, L.).

About 700 single plant paddy cultures were grown and studied in detail. The work is in progress.

Urid and Mung (*Phaseolus Mungo*, L., and *P. radiatus*, L.).

Isolation of pure strains and maintenance of types thus evolved is still in progress.

Hemp (*Cannabis sativa*, L.).

The study of the effect of external stimuli on the sex-ratios of the Indian hemp has been completed, and the results obtained have been incorporated in an article in the *Agricultural Journal of India*. Some details of this have already been published in the last annual report.

Chillies (*Capsicum annuum*, L., and *C. frutescens*, L.).

Types. The 52 types described in *Memoir, Botanical Series*, XVI, No. 2, 1928, were maintained.

Seed samples of 20 types were received from the Director of Agriculture, Goa (Portuguese India), and were grown. Most of them were found to be splitting for habit of plant, size and shape of fruit, etc. When isolated and fixed, some of these may prove to be different from our original types, but none seems to be superior to our best types.

The four high yielding types—34, 41, 46 and 51—were grown on field scale, each being given an acre. The land available was not very uniform. T. 41 has given the highest yield this year. The plot given to T. 46 was rather inferior. T. 51 suffered from diseases such as wilt and die-back, perhaps due to its being grown on a low-lying area.

Statement showing the comparative yields of the 4 types since 1928-29.

Type No.	Yield per acre in lb.					Remarks.
	1928-29	1929-30		1930-31		
			(dry weight)		(dry weight)	
34	3,325	2,300	793	6,591	1,648	
41	6,358	3,236	921	10,173	2,180	
46	6,600	2,843	1,121	3,713	858	The plot was poor.
51	5,430	2,604	864	5,158	1,074	Many plants died of wilt and die-back.

Hybridization. The F_3 generation of the cross T. 3 × T. 29 was grown and confirmation was obtained of the monohybrid theories put forth to explain the F_2 segregations of the two sets of allelomorphic

characters, *viz.*, (1) pendent and erect fruit-position (pendent being dominant to erect on a 3 : 1 basis) and (2) red and orange colour of ripe fruit (red being dominant to orange also on a 3 : 1 basis).

Regarding the purple colour in the vegetative and floral organs, the results of F_3 showed that this character is due to two factors and not to one as supposed in the study of F_2.

The F_2 of the reciprocal cross, T. 29 × T. 3, was also grown and results very similar to those of the original cross, T. 3 × T. 29, were obtained.

Besides this, two F_2 generations of the two crosses, T. 29 × T. 4 and T. 29 × T. 14, were also grown. In the former, the red colour of ripe fruit behaved as in the previous cross, T. 3 × T. 29, on a 3 red : 1 orange basis.

"Hairiness" was found to be due to two cumulative factors, each equal in its effect, giving an intermediate F_1, and segregating in F_2 on a 15 hairy (different grades) : 1 smooth basis.

"Corrugation" of fruit surface was indicated to be due probably to many cumulative factors giving an intermediate F_1. In F_2 two individuals like each of the two parents were realised in a population of a little over 500.

As regards the other cross—T. 29 × T. 14—the only important points of differences studied were "pungency" and "size" of fruit. The F_1 was intermediate both for pungency and size and gave in F_2 a 3 pungent : 1 non-pungent ratio.

An investigation was carried out on the cytology of *Capsicum annuum*, Linn., and it was found out that the diploid number of chromosomes was 24. The results of this investigation have been embodied in a paper entitled "A cytological study of *Capsicum annuum*, L.," which has been sent for publication.

Hibiscus (*Hibiscus cannabinus*, Linn., and *H. Sabdariffa*, L.).

The various types of *H. cannabinus* and *H. Sabdariffa* were maintained.

Some seed of *H. Sabdariffa* variety *altissima*, a type commonly grown in the Philippines, was received from the Director of Agriculture, Philippines, and was sown. This type seems to be the same as the "New Pusa Hemp" isolated here.

About two acres were grown under the New Pusa Hemp for seed multiplication.

Some seed of this variety was sent to the Fibre Expert to the Government of Bengal, Dacca, who grew it at Dacca and other places in the Western Bengal. Reports regarding this variety from all the places were satisfactory. The Fibre Expert intends to give this hemp a thorough trial next season when quality of the fibre also will be tested.

Hybridization. The F_1 generations of the two varietal crosses, New Hibiscus × *H. Sab. Albus*, and New Hibiscus × *H. Sab. Ruber*,

were grown with their reciprocals and some important characters were studied which are shown in the following table :—

Table showing the important characters of the parents and the two F_1s.

Characters	*H. Sab.* var. *Albus*. Parent	*Albus* × New Hibiscus F_1	*H. Sab.* var. *altissima* (New Hibiscus). Parent	*Ruber* × New Hibiscus F_1	*H. Sab.* var. *Ruber*. Parent
Habit	Bushy and not so tall as New Hibiscus.	Taller than either parent, intermediate for bushiness.	Tall, erect, without branches.	Taller than either parent but intermediate for bushiness.	Bushy and not so tall as New Hibiscus.
Stem	Green, smooth	Red, intermediate in hairiness.	Green in early stages, except in leaf axil and below it but becomes red towards maturity.	Red, intermediate in hairiness.	Red, smooth.
Leaf-lobes	Broad	Intermediate.	Narrow	Intermediate.	Broad.
Eye of corolla	Colourless (Pale yellow).	Red	Red	Red	Red.
Stigma	Ditto	Deep red	Very deep purple.	Intermediate	Deep red with a purplish tinge.

It will be seen from the above table that the two F_1s are almost exactly similar in all respects except in the stigma colour which is a little lighter in the F_1 of the cross *Hibiscus Sab. Albus* × New Hibiscus than in that of the cross *H. Sab. Ruber* × New Hibiscus.

The presence of red colour in the stem, in the F_1 of the cross, *H. Sab. Albus* × New Hibiscus, suggests that it is due to the presence of two complementary factors, one in each of the parents.

III. OUTTURN STATEMENTS OF DIFFERENT CROPS.

1. Statement showing the yields of crops in the Botanical Section in 1930-31.

Crop	Plot	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Wheat—				
P. 4	Barah 4	0·75	911	1,216
P. 6	Orchard 3-B, E.	0·27	450	1,667
P. 12	N. T. G. 5	1·0	1,479	1,479
P. 52	Farm Plot (outside)	0·98	878	896
P. 80-5	Orchard 6-B	1·44	2,626	1,823

1. STATEMENT SHOWING THE YIELDS OF CROPS IN THE BOTANICAL SECTION IN 1930-31—*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Wheat—contd.				
P. 101 . .	S. T. G. 8 . . .	0·30	398	1,326
P. 111 . .	Pentagonal . . .	4·0	4,166	1,041
P. 115 . .	Orchard 6-A, E. . .	0·52	973	1,871
P. 163 . .	„ 3-B, W. . .	0·27	389	1,441
Oats—				
B. S. 1 . .	N. T. G. 8 part . .	0·17	318	1,871
„ . .	N. T. G. 9 part . .	0·20	392	1,960
B. S. 2 . .	N. T. G. 8 part . .	0·17	281	1,653
„ . .	N. T. G. 9 part . .	0·20	330	1,650
Linseed—				
Type 121 . .	Riverbank W. . . .	0·74	816	1,103
„ 124 . .	S. T. G. 1 . . .	0·51	438	859
„ 12 . .	Barah 5	0·47	492	1,047
Gram—				
Type 17 . .	Barah S. Border . .	0·45	383	851
„ . .	Mosahars inside Plot No. 2	0·22	213	968
„ . .	Mosahars inside Plot No. 5	0·22	98	445
Rahar—				
Type A_2 . .	S. T. G. 4 . . .	0·30	422	1,407
„ A . .	Orchard 2-A . . .	0·71	322	454
„ A . .	„ 2-B . . .	0·71	268	378
„ E . .	„ 2-C . . .	0·71	582	820

1. STATEMENT SHOWING THE YIELDS OF CROPS IN THE BOTANICAL SECTION IN 1930-31—*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Patwa—				
Type New . .	Riverside E. . . .	0·50	131(1) 269(2)	262(1) 538(2)
Tobacco—			(Outturn of cured leaf.)	
Type 49 . .	Orchard 4-B part . .	0·90	408	453
Hybrid 142 . .	„ „ . .	0·70	408	583
„ 164 . .	„ „ . .	0·40	116	290
„ 177 . .	Lawn plot No. 3 part .	0·83	91	1,094
Type 63 . .	„ „ . .	0·83	98	1,180
„ 72 . .	„ „ . .	0·83	116	1,402

(1) Seed. (2) Fibre.

2. STATEMENT SHOWING THE OUTTURNS OF IMPROVED VARIETIES FROM THE BOTANICAL SECTION GROWN ON PUSA FARM DURING 1930-31.

Crop	Plot	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Wheat—				
P. 4 . . .	Nepali	11·5	10,686	929
P. 52 . . .	„	11·0	14,208	1,291
P. 12 . . .	South Pangarbi . .	15·0	16,010	1,067
Oats—				
B. S. 1 . .	Mysore Field . . .	15·25	18,497	1,213
Hybrid A . .	Punjab Guntha Plots, Block D.	0·50	1,096	2,192
Barley—				
Type 21 . . .	Middle Pangarbi . . .	6·0	9,838	1,640

2. STATEMENT SHOWING THE OUTTURNS OF IMPROVED VARIETIES FROM THE BOTANICAL SECTION GROWN ON PUSA FARM DURING 1930-31—*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Linseed—				
H 2	Gonhri	1·0	298	298
H 10	„	1·0	334	334
H 11	„	1·0	357	357
H 13	„	1·0	331	331
H 63	„	1·0	264	264
Gram—				
T. 17	Gonhri	5·0	5,252	1,050
T. 28	„	2·0	1,776	888
T. 25	„	4·0	3,146	786
T. 58	„	1·5	1,454	969
Rahar—				
Type B	Jhilli	2·0	2,152	1,076
„ E	„	1·0	689	689
„ H	„	2·0	1,483	741
„ G	„	2·0	1,154	577
„ S	„	2·0	1,315	657
„ T	„	2·0	2,215	1,107
„ A_4	„	9·0	5,432	604
Patwa, New Type	Gonhri	2·0	277	138

IV. PUBLICATIONS AND PROGRAMME.

PUBLICATIONS.

1. SHAW, F. J. F. . . The Mathematical Probable Error as Applicable to Field Experiments in Agriculture, by Prof. M. Vaidyanathan, M.A. (Review.) *Agri. Jour. India*, 25, 1930, 461-462.

2. Shaw, F. J. F., Abdur Rahman Khan, and Alam, M.	Studies in Indian Oil-seeds. (5) The Inheritance of Characters in Linseed. *Indian Jour. Agri. Sci.*, Vol. 1, 1931, 1-57.
3. Abdur Rahman Khan .	Some observations on the Pollination of Peaches (*Prunus persica* Benth. and Hook). *Agri. Jour. India*, Vol. 25, 1930, 492-494.
4. Shaw, F. J. F., Bose, R. D., and Narasingha Rao, M. B. V.	Further Yield trials with some Pusa Barleys. *Agri. Jour. India*, Vol. 25, 1930, 527-530.
5. Shaw, F. J. F., and Abdur Rahman Khan.	Studies in Indian Pulses, No. 2. Some varieties of Indian Gram. *Mem. Dept. Agri. in India, Bot. Ser.*, Vol. 19, No. 2, 1930.
6. Bose, R. D. . . .	A study of Sex in Hemp. *Agri. Jour. India*, Vol. 25, 1930, 495-507.
7. Bose, R. D. . . .	Studies in Indian Barleys: (1) Classification of Types isolated at Pusa. *Indian Jour. Agri. Sci.*, Vol. 1, 1931, 58-89.
8. Bose, R. D., and P. D. Dixit.	Studies in Indian Barleys: (2) The Root-system. *Indian Jour. Agri. Sci.*, Vol. 1, 1931, 90-108.
9. Shaw, F. J. F. . .	Milling and Baking Tests with some Indian Wheats grown at Pusa and at Mirpurkhas (Sind). *Indian Jour. Agri. Sci.*, Vol. 1, 1931, 395-414.
10. Shaw, F. J. F. . .	Summary of the Progress of Research in Agricultural Botany for the year ending 31st March 1931, for inclusion in the Report of the Privy Council.
11. Dixit, P. D. . .	A Cytological Study of *Capsicum annuum*. *Indian Jour. Agri. Sci.*, Vol. 1, 1931, 419-433.
12. Khanna, K. L. . .	Some Observations on Bamboos. *Indian Jour. Agri. Sci.*, Vol. 1, 1931, 473-479.
13. Chowdhry Ali Mohammad.	Some Investigations into the effect of Fertilizers on the Growth and Oil-content of a variety of Linseed (*Linum usitatissimum*). *Agri. Jour. India*, Vol. 25, 1930, 471-486.
14. Kasi Ram . . .	The Improvement of Indian Cigarette Tobacco by Hybridization. *Indian Jour. Agri. Sci.*, Vol. 1, 1931, 455-472.

Programme for 1931-32.

Investigations will be continued on the lines indicated in this report on the following crops :—wheat, barley, oats, paddy, maize, tobacco, chillies, linseed, gram, *rahar*, peas and other pulses. The training of students will proceed as in past years.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(B. A. Keen, D.Sc., F. Inst. P.)

I. CHARGE.

Dr. J. Sen held charge of the Section till 6th November, 1930, when Dr. W. H. Harrison took over. Dr. B. A. Keen took over charge on 7th March, 1931, when Dr. W. H. Harrison proceeded on leave preparatory to retirement.

II. EDUCATION.

Mr. R. S. Chaturvedi, B.Sc., from the Indore State, was admitted to the post-graduate course in November, 1930, and is continuing his studies.

III. METEOROLOGY AND DRAIN-GAUGES.

The usual meteorological records and records of drainage from four drain-gauges were maintained. In this connection sann-hemp and wheat crops from the gauges and 27 samples of drainage waters were examined.

IV. GENERAL ANALYTICAL WORK AND ASSISTANCE GIVEN TO OTHER SECTIONS.

1. General analytical work.

The following samples were analysed and reported upon—

Soils	21
Manures	9
Feeding stuffs	11
Oil-seeds	108
Sugarcanes	379
Butter	50
Milk	2,511
Waters	2
Engine oil	7
Miscellaneous	1
Total	3,097

Two samples of soil were received from Mr. Rutherford of Rajaputtee, Saran District. They contained a fair amount of alkali salts which seriously interfered with the germination of seeds and growth of any plants. Of the samples of feeding stuffs examined, four were those of *bhoosa*, barley, bran, and grass sent from the Military Dairy Farm, Meerut, where two cases of fatality and several of illness in horses fed

on these materials had occurred. None of these samples contained any prussic acid but the sample of grass was highly infected with moulds possessing very offensive smell and was quite unsuitable for use as a feeding stuff.

Analysis of a sample of water from the river Malezai was carried out for the Executive Engineer, Irrigation Department, Baluchistan. The water was saline and was unsuitable for irrigation purposes.

At the request of Messrs. Finlay, Fleming & Co., Limited, Rangoon (made through the Secretary, Sugar Bureau, Pusa), an investigation into the causes of poorer growth of sugarcane in black soil at Sahmow in Burma, compared to that grown in laterite soil, was taken up. The Estate Manager suggested that the presence of sodium and magnesium salts in the low-lying black soils caused the poor outturn, but the analytical data did not bear out the suggestion. There were no harmful amounts of water-soluble salts in either of the two soils. The laterite soil is richer in the content of alkaline earths and alkalies. Determination of the lime-magnesia ratios gave low value in each case, 0·57 in the laterite and 0·23 in the black soil. Various investigators have noted that salts of magnesium possess a toxic action upon plant roots, which is much diminished if calcium salts be present at the same time. Hence the occurrence of a low lime-magnesia ratio in the black soil indicates to a certain extent its poorness in comparison to the laterite soil. The black soil contains more of the finer fractions in its mechanical composition than does the laterite soil, and laboratory determinations showed that water percolated through the laterite soil five times as rapidly as through the black soil. The bad mechanical condition of the black soil appears to be mainly responsible for the poorer tonnage and stunted growth of canes in this area.

2. Assistance rendered to other Sections.

Agricultural Section. Five samples of manures, 15 samples of soil, 320 samples of sugarcane in connection with the farm's variety test and manurial experiments, and 2,511 samples of milk were analysed.

Milk of four Montgomery and four cross-bred (Ayrshire-Montgomery) cows was examined twice daily throughout the full course of their lactation periods. The increase in fat-content with the progress of the lactation period was observed as in previous years. These determinations have now been discontinued.

Botanical Section. Six samples of barley were tested for their malting values. One sample of wheat, two of mixed fertilizers and 108 samples of linseed were examined.

Mycological Section. A sample of superphosphate and 46 samples of sugarcane, in connection with the experiments on the mosaic disease of sugarcane, were examined.

Entomological Section. Thirteen samples of sugarcane were analysed in connection with the experiment on sugarcane borers.

Imperial Dairy Section. Fifty samples of butter were received from the Government Creamery, Anand, and were examined at the request of the Imperial Dairy Expert, Bangalore.

Power House, Pusa. Seven samples of engine oil sent by the Electrical Engineer, Pusa, were tested for their specific gravity and acidity.

V. RESEARCH.

1. Crops.

Permanent manurial plots. Experiments on the influence of manures on the yield and composition of crops which were started in 1920 are being systematically carried on. The experiment is being carried out in a series of nine plots having the following manurial treatment—(1) no manure, (2) oil-cake, (3) nitrogen, phosphate and potash, (4) nitrogen and phosphate, (5) nitrogen and potash, (6) phosphate and potash, (7) nitrogen, (8) phosphate, and (9) potash. The manures are applied at the rate of 80 lb. nitrogen (as ammonium sulphate), 40 lb. phosphoric acid (as superphosphate), and 40 lb. potash (as potassium sulphate) per acre. The amount of oil-cake applied corresponds to 80 lb. nitrogen per acre. The manures are applied once every year just at the beginning of the monsoon. Every season, the yields (total as well as those of the constituents, *viz.*, grain, chaff and straw) from each of the plots are recorded, and the amounts of nitrogen, phosphate and potash in the different constituents of each crop are determined.

A preliminary examination of the figures for yield of crops from these plots during the last six years (1925—1931) shows that so far as the *kharif* (summer) crop is concerned, the use of nitrogen alone has considerably increased the yield, and, in combination with potash or phosphate, it has given even better results. Of the two combinations mentioned above, the one with phosphate responds better than one with potash. Phosphate alone has shown some effect but, in combination with potash, the effect is more marked. Potash alone has little or no effect; in fact, it has a gradual tendency towards decreasing the yield. The application of a complete manure has produced the best results, and no consistent superiority of the complete mineral manure over the oil-cake is shown.

The observations made in the case of the *kharif* crop, with regard to the effect of (*a*) nitrogen or phosphate alone, (*b*) the combination of nitrogen and phosphate, and (*c*) the combination of nitrogen or phosphate with potash, hold good in the case of the *rabi* (winter) crop too, but the effect, being a residual one, is not so marked. Potash in the case of the *rabi* crop invariably gave a lower yield than the control, and its depressing effect was more marked here than in the case of the *kharif* crop. The effects of a complete mineral manure (N+P+K) and oil-cake were very marked, the latter proving definitely the better.

Experiment on curing of tobacco. The quality of a tobacco depends on various properties such as burning quality, size, elasticity, colour, fermentative properties and aroma, and these in turn depend upon some of the chemical constituents of the tobacco plant. The amido nitrogen in tobacco represents, for the most part, harmless or even beneficial nitrogenous compounds, and the conversion of albuminoids into amides is one of the most important results of the fermentation. In previous years attention was confined to the examination of starch, sugar, nicotine and amido nitrogen contents (constituents which have been recognized to possess a direct bearing on the quality), both in the uncured stage and after curing by different processes, with a view to correlate the figures with the actual results obtained and to study the changes in, or rather the destructive changes undergone by, the constituents during the process of curing. During the year under review, attention was directed more towards an examination of amido and albuminoid nitrogen and the ash and potash contents in samples of tobacco cured by the five different processes.

The albuminoids in a tobacco afford no indication of quality unless the proportion of amides is simultaneously considered. Similarly a high content of potash in a sample of tobacco will not improve its fire-holding capacity unless it is present mostly in combination with organic acid together with a minimum amount of inorganic salts. Hence the ratio of albuminoid nitrogen to amido nitrogen and the ratio of ash (mineral matter) to potash in a sample of tobacco will indicate its quality more properly than each of these constituents considered separately. The following table gives the ash, potash, albuminoid nitrogen and amido nitrogen contents under various processes of curing :—

Method of curing employed	ADCOCK, 1929-30					
	Albuminoid nitrogen	Amido nitrogen	Albuminoid N / Amido N	Ash	Potash	Ash / Potash
	Per cent.	Per cent.		Per cent.	Per cent.	
I. Cured on ground (country method)	1·14	0·185	6·16	19·10	1·92	9·90
II. Cured on racks in sun protected from dew—						
(1) Lower leaves	1·18	0·270	4·37	18·54	2·97	6·25
(2) Upper leaves	1·09	0·328	3·32	12·23	1·74	7·02
(3) Mean of lower and upper leaves	1·14	0·30	3·84	15·39	2·35	6·63
III. Cured on racks in sun unprotected from dew for 3 days, after which protected from dew for 10 days and finally cured in shade—						
(1) Lower leaves	1·38	0·251	5·50	14·24	1·89	7·53
(2) Upper leaves	1·08	0·276	3·91	13·25	2·29	5·79
(3) Mean of lower and upper leaves	1·23	0·265	4·70	13·74	2·09	6·66
IV. Cured on racks in sun unprotected from dew all through—						
(1) Lower leaves	..	..	..	..	..	..
(2) Upper leaves	0·97	0·275	3·53	14·22	1·85	7·71
(3) Mean of lower and upper leaves	..	..	..	..	..	..
V. Cured on racks in shade all through—						
(1) Lower leaves	1·00	0·288	3·47	15·93	1·65	9·65
(2) Upper leaves	0·79	0·294	2·68	16·25	2·12	7·67
(3) Mean of lower and upper leaves	0·90	0·290	3·08	16·09	1·89	8·66

Method of curing employed	Pusa Type 28, 1929-30					
	Albuminoid nitrogen	Amido nitrogen	Albuminoid N / Amido N	Ash	Potash	Ash / Potash
	Per cent.	Per cent.		Per cent.	Per cent.	
I. Cured on ground (country method)	1·19	0·24	4·96	19·70	1·79	11·00
II. Cured on racks in sun protected from dew—						
(1) Lower leaves	0·85	0·275	3·09	18·48	1·88	9·85
(2) Upper leaves	1·35	0·367	3·67	15·82	2·02	7·83
(3) Mean of lower and upper leaves	1·20	0·32	3·38	17·15	1·95	8·84
III. Cured on racks in sun unprotected from dew for 3 days, after which protected from dew for 10 days and finally cured in shade—						
(1) Lower leaves	0·94	0·26	3·62	17·40	1·81	9·61
(2) Upper leaves	1·13	0·31	3·64	15·95	1·68	9·52
(3) Mean of lower and upper leaves	1·03	0·285	3·63	16·68	1·74	9·56
IV. Cured on racks in sun unprotected from dew all through—						
(1) Lower leaves	1·23	0·22	5·58	18·76	2·78	6·76
(2) Upper leaves	1·41	0·36	3·92	16·62	2·47	6·73
(3) Mean of lower and upper leaves	1·32	0·29	4·75	17·69	2·62	6·75
V. Cured on racks in shade all through—						
(1) Lower leaves	1·07	0·335	3·19	18·30	3·14	5·83
(2) Upper leaves	1·03	0·335	3·08	16·49	2·19	7·54
(3) Mean of lower and upper leaves	1·05	0·335	3·14	17·40	2·66	6·69

Method of curing employed	ADCOCK, 1928-29					
	Albuminoid nitrogen	Amido nitrogen	Albuminoid N / Amido N	Ash	Potash	Ash / Potash
	Per cent.	Per cent.		Per cent.	Per cent.	
I. Cured on ground (country method)	2·38	0·56	4·25	20·06	1·72	11·66
II. Cured on racks in sun protected from dew—						
(1) Lower leaves	2·01	0·52	3·85	17·25	2·18	7·91
(2) Upper leaves	2·48	0·56	4·47	15·59	1·28	12·18
(3) Mean of lower and upper leaves	2·25	0·54	4·16	16·42	1·73	10·04
III. Cured on racks in sun unprotected from dew for 3 days, after which protected from dew for 10 days and finally cured in shade—						
(1) Lower leaves	2·24	0·65	3·45	16·33	1·34	12·20
(2) Upper leaves	2·49	0·59	4·24	17·47	1·61	10·85
(3) Mean of lower and upper leaves	2·36	0·62	3·84	16·90	1·48	11·52
IV. Cured on racks in sun unprotected from dew all through—						
(1) Lower leaves	2·38	0·54	4·41	19·85	1·64	12·10
(2) Upper leaves	2·21	0·57	3·88	15·64	1·57	9·96
(3) Mean of lower and upper leaves	2·30	0·55	4·15	17·75	1·61	11·03
V. Cured on racks in shade all through—						
(1) Lower leaves	2·29	0·43	5·32	18·18	2·08	8·74
(2) Upper leaves	2·38	0·60	3·97	16·42	1·45	11·32
(3) Mean of lower and upper leaves	2·33	0·52	4·65	17·30	1·77	10·03

Ground-cured tobaccos were cured with their stalks on, whereas in the case of rack-cured samples the leaves were removed from their stems at the time of harvest and the lower and the upper leaves cured separately. Hence in comparing the figures for the rack-cured samples with those of the ground-cured, only the mean values of the lower and the upper leaves have to be taken into account. Among the cured samples so far examined, both the albuminoid ratio and the ash-potash ratio were generally found to be the highest in the case of ground-cured samples, thus indicating that this process is invariably inferior to any of the different rack-curing processes. In the rack-cured samples, the albuminoid ratio as well as the ash-potash ratio, though varying between wide limits, seemed hardly affected by any of the four different processes. It was noted that the upper leaves in all the varieties and under all the processes of curing are generally richer than the lower ones, both in nicotine and amido nitrogen contents. Moreover, in the majority of cases, it was observed that the albuminoid ratio in upper leaves was less than that in lower ones, thus affording an explanation to the superiority of the upper to the lower leaves in actual practice.

Experiments at Bilari on the manufacture of sugar by indigenous method. Sugar manufacture is one of the vitally important industries, but, owing to the backward stage of development in the country, a multiplication of well equipped up-to-date power factories is difficult. Khan Bahadur S. M. Hadi's process of open pan sugar manufacture is a modification in the indigenous method of sugar manufacture as followed in Rohilkhund, and it lays claim to superiority over the latter in certain respects. It is maintained to be fairly simple and easily adoptable by the indigenous manufacturers. Last year, at the instance of the Imperial Council of Agricultural Research, Messrs. P. B. Sanyal and M. A. Hossain of this Section were deputed for a month and a half to conduct a series of trials with the Hadi process at Bhopal, and at the conclusion of the work Mr. Sanyal submitted a report to the Imperial Council of Agricultural Research. The report was considered and discussed at a meeting of the Sugar Committee held at Poona in September last, when it was decided that a full season's test and comparison of the *Hadi process* with the existing *Rohilkhund Bel method* be undertaken on a commercial scale with proper chemical control in order to form a basis of comparison with modern factory figures. Accordingly, at the request of the Imperial Council of Agricultural Research, the services of two senior assistants Messrs. P. B. Sanyal and S. L. Das, of this Section were temporarily transferred, for about 4 months from 9th January to 30th April, 1931, under the Council in order to carry on these experiments at Bilari in the district of Moradabad, United Provinces. The results obtained at Bilari show that while by the Rohilkhund Bel method 6·47 per cent. sugar on cane and 10·06 per cent. sugar on juice was obtained, by the Hadi process 7·76 per cent. sugar on cane and 12·14 per cent. on juice was recovered. The Hadi process thus gave a higher yield of sugar by about 1·3 per cent. calculated on sugarcane. A comparison of the results obtained at Bilari in 1931 with those at Bhopal in 1930

shows that 0·83 per cent. more sugar calculated on cane was obtained at Bhopal. This increase in yield at Bhopal was due to the average sucrose content of the cane juice at Bhopal being 17·50 per cent. as against 16·09 per cent. at Bilari and the purity of the former being 3 per cent. higher than that of the latter. In addition the extraction of juice at Bhopal was on the average 66·3 per cent. as against 63·9 per cent. at Bilari. Taking these factors into consideration, the results of the Hadi process worked on a commercial scale at Bilari gave almost similar values as obtained with the smaller tests at Bhopal last year. A full report has been prepared and forwarded to the Imperial Council of Agricultural Research.

Experiment on the production of artificial gur from a mixture of Java brown sugar and molasses. In compliance with the request made by the Secretary, Imperial Council of Agricultural Research, to the Director of this Institute (in connection with the Tariff Board's enquiry into the question of protection to be afforded to the sugar industry), an investigation was carried out by Mr. P. B. Sanyal to find what proportion of molasses can be mixed with Java brown sugar to produce a good quality *gur*. Experiments were carried out on mechanical mixing of the two ingredients, and also by melting them together. In regard to the first alternative, molasses and brown sugar were mixed together in several proportions varying from 5 to 35 per cent. molasses and the mixtures well pressed. As a result it was found that those containing 5 to 10 per cent. molasses were very loose in texture, those with 15 to 25 per cent. were fairly hard and compact, whereas those with more than this proportion were soft and unserviceable. In all cases even with the use of crushed and sifted sugar, the resulting mixtures were gritty and lacked the appearance of commercial *gur*. Better success was obtained when the second alternative was tried. The brown sugar together with the requisite quantity of molasses was dissolved in the minimum quantity of hot water, and the solution then boiled down in an iron pan on a country furnace until the temperature reached 114°C., when it was poured into moulds to set to cakes of *gur* each weighing 16 to 22 lb. The cakes containing 15 to 18 per cent. molasses were hard but too brittle to form a practicable *gur*; those with 19 to 23 per cent. molasses were hard and compact and of good quality; whilst those with quantities from 24 to 25 per cent. were softer and of dubious keeping quality. *Gur* prepared with country molasses was bright in colour and possessed an excellent flavour, but those made with Java molasses were dark and strongly flavoured.

Potato storage experiments. Mr. P. B. Sanyal continued the experiment on the storage of potatoes during the year. The seed potato preserved till November 1930 was 49 per cent. of the weight of the freshly dug out potato, whereas that preserved in 1929 was only 42 per cent. If this difference is significant it can probably be attributed to the higher maximum temperatures in 1929 (110·1°F. as against 107·8°F. in 1930), as it has already been demonstrated that rot increases with temperature.

A preliminary study of the effect of temperatures slightly higher than that of the atmosphere was made on potato tubers (1) sound and unscratched, (2) with scratches made on the skin, (3) sound, unscratched, but smeared with potato rot emulsion, (4) scratched and smeared with potato rot emulsion, (5) sound and dipped in 2 per cent. copper sulphate solution for half an hour, (6) dipped in 2 per cent. copper sulphate solution for half an hour, and smeared with potato rot emulsion, and (7) sound and unscratched but possessing rough skin. The results show that (*a*) copper sulphate solution cannot be regarded as a sufficient preventive to heat rot, and that (*b*) the infection of both scratched and unscratched tubers smeared with potato rot emulsion does not take place immediately if they are kept dry. The most effective way, therefore, of preserving potato from heat rot appears to be to store them in a dry cool place in heaps not more than 6 to 8 inches in depth and to pick out occasionally the rotted potatoes.

Experiment on the malting of barley. In connection with the examination of barley for malting, received from the Imperial Economic Botanist, Mr. A. C. Ukil examined the optimum conditions under which the malting should be conducted in order to ensure the highest diastatic activity. Determinations were therefore made on the malted barley in which (1) plumules were just allowed to come out of the grain, (2) plumules grown in length equal to the length of the grain, and (3) with plumules grown in length about 1·5 to 2 times the length of the grain. The drying of the malted grain was carried out at temperatures starting from 25°C. and increasing by stages to a final temperature of 85°C. It was found that the raising of temperature above 80°C. and keeping over night at this temperature caramelises the malted grain to such an extent that there is a considerable loss of diastatic activity. The greatest diastatic activity was observed when the plumules were allowed to grow to a length almost equal to the length of the grain and when the grains were dried by stages to a final temperature not exceeding 65°C.

2. Soils and Fertilisers.

Alkali soil investigations. Dr. J. K. Basu has taken up investigations in connection with alkali soils with a view to elucidate some of the characteristics of the Indian "Reh" lands. Considering the vast tracts of alkali lands which can be made productive by a suitable method of soil management, the importance of this kind of work is self-evident.

In this connection samples of (*a*) soil from bad patches, down to a depth of 24 inches, in Harpur Jhilli, Pusa, where sugarcane was growing very badly and also from the adjoining fertile plot, and (*b*) alkali soils from Sakrand, Sind, down to a depth of 46½ inches, were examined for their total water-soluble salts, the cations (Ca, Mg, K, Na) and the anions (SO_4, Cl, CO_3).

With regard to the Pusa soil, it was found that the total salts, which exceeded 2 per cent. by weight, in the top 3 inches of the bad soil were 10 to 12 times more than those in the adjoining good soil. Sodium

sulphate was the predominant constituent in the soluble salts and the amount of sodium carbonate was very small, although the soils are highly calcareous. The failure of crops in these alkali patches may be due either to the retardation of nitrification through high salt-content or to plasmolysis of the cell saps of the young plant by the high concentration of the salt.

With regard to the alkali soils of Sakrand (Sind) from the *kalar* area, the soil reaction of the whole profile shows that the medium is alkaline and that the distribution of the ions throughout would be such as to favour the formation of a " solenetz " soil in time.

The process of solonization is characterized by two distinct phases : (1) In an alkaline medium accumulation of the salts of alkali metals takes place in the surface horizon ; (2) the second is a base-exchange process, in which calcium from the zeolite humus complex is replaced by sodium, giving rise to a sodium complex with the characteristic structure of a solonetz soil. Exchanged cations go into solution and are washed down into deeper horizons. This results in the accumulation of gypsum in the sub-soil in the form of a hard pan. From the data obtained so far on the water extracts of Sakrand soil, this striking tendency of the monovalent ions to rise to the surface and the bivalent ions to leach downwards has been clearly exhibited. Existence of a hard gypsum layer has also been noted at a depth of $18\frac{1}{2}''$ to $24\frac{1}{2}''$. Further work in this connection is in progress.

Utilization of bones as manure. The difficulties in utilising, as a manure for Indian soils, the large quantity of bones now exported are mainly the strong prejudice of the cultivators, and their inability to obtain a finely crushed material with the means at their command. Prejudice can only be overcome slowly, and by demonstration of the crop increases obtained. The second difficulty, that of producing an easily pulverisable material from the crude bone, is being studied at the request of the Fertilizers Committee of the Imperial Council of Agricultural Research ; the following methods are under investigation : (1) treatment with superheated steam, (2) treatment with solutions of easily available chemicals, (3) fermentation in composts. Two other methods are possible : calcination, and the use of solvents to leave a friable residue ; but attention has been confined to the first three.

(1) *Treatment with superheated steam.* The action of steam under pressure is employed in many bone treatment establishments. Our experiments demonstrated that autoclaving pieces of three to four inches length, for two hours at 130°C., yielded very good products. Big bones about 18″ long had to be maintained at 130°—135°C. for three to four hours. When the temperatures were maintained lower than 130°C. a longer period was necessary, *e.g.*, at 120°C. it was necessay to heat the bones for six hours or more. The bones were rendered friable enough to be powdered with gentle pressure. Where the object is to render them only sufficiently brittle to be capable of being broken up with the help of a country *dhenki*, two hours' heating at 130°C. should do.

During the process of heating volatile products escaped with the steam and some material dissolved in the water. In the solid residue there is a loss of nitrogen but the phosphoric acid is conserved. Analysis of a sample of raw bones showed that there was about 4·5 per cent. nitrogen and 27 per cent. phosphoric acid (calculated on a dry basis). The steamed bone was found in one experiment to contain 1·8 per cent. nitrogen and 31 per cent. phosphoric acid. After the treatment there remained in the aqueous liquid 1·52 grm. nitrogen and 0·008 grm. phosphoric acid for every 100 grm. raw bones taken.

(2) *Treatment with solutions of easily available chemicals.* The action of solutions of various mineral salts on bones at ordinary temperatures and in the heat was slight. Signs of yielding were observed only with alkali carbonates. Solutions of caustic alkalis gave much better results, and the addition of sodium chloride seemed further to favour the reaction. Trials were, therefore, conducted with solutions of various strengths of carbonates and hydroxides of sodium and potassium with and without the addition of sodium chloride. The higher the strength of caustic alkali, the quicker the reaction occurred, but there was a limit of period of activity after which the reaction proceeded at a very slow rate ; this period varied with the strength of alkali, being shorter in the case of stronger solutions. In the case of caustic soda solutions of strength below 1·5 per cent. and with caustic potash solutions below 2 per cent. in strength, the disintegration seemed to be negligible. The presence of sodium chloride was of help in accelerating the action. The prevailing atmospheric temperature is also of significance.

Keeping the bones in 1·5 per cent. caustic alkali for three months disintegrated only half of them, while in the case where 1 per cent. common salt was used in addition three-fourths of the bones were broken up during the course of two months. The bulk of the reaction, however, took place within 40 and 30 days respectively. The less resistant portions are the first to yield, the action gradually proceeding to the more resistant fractions but some portions (*e.g.*, some of the shafts and joints and specially the teeth) are very refractory and escape disintegration.

In these experiments bones were taken to be " disintegrated " when it was possible to break them up to coarse powder with gentle pressure in a porcelain mortar. The residual pieces of bones (which, as noted, amounted to about a quarter of their original weight) were after the treatment left in a loosened and peculiarly laminated condition. Much of these latter could be broken off by hand in the form of flakes. Vigorous pounding could also serve to crush them.

Chemical analyses showed that disintegration through the agency of alkali was associated with leaching out of organic matter. The product was poorer in nitrogen and richer in phosphoric acid, and hence the solution contained mainly organic matter.

The solution of alkali and salt used for disintegration can be used again if the requisite amount of caustic soda is added to make it up to

the original strength. With this procedure it can be used at least three times.

The differential response of hard and softer portions of the skeleton to the alkali treatment is shown by the following results :—

	Organic matter		Nitrogen		Phosphoric acid	
	Hard	Soft	Hard	Soft	Hard	Soft
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Raw bones . . .	27·78	33·32	4·02	4·35	28·38	25·38
Alkali-treated bones (average of nine samples).	27·35	26·66	3·82	3·66	27·80	26·86

The difference in the organic content of the two fractions and the influence of the alkali on the organic matter are brought out in the above data.

The laboratory experiments in glass vessels were then repeated on a larger scale suitable for the cultivator, kerosene tins and masonry pits being used for this purpose. From the practical point of view 1·5 per cent. NaOH is to be preferred to 2 per cent., for the bones with the weaker solution, although softened, were easy to handle and the operations of washing and recovering the treated bones could comfortably be managed. With the stronger solution of alkali, disintegration proceeded too far and the product became sludge-like, which made it very troublesome to wash out the alkali and to recover the product.

It is to be noted that the vessels should be protected from the action of the atmospheric carbonic acid which would otherwise serve to reduce the strength of the alkali.

This method appears promising. It is simple, and the cost should not be excessive, since the mixture if made up to strength can be used again.

(3) *Fermentation in composts.* It is known that when bone-meal is placed in heaps with suitable composting materials and appropriate conditions for fermentation are maintained, it enters into putrefaction and becomes a much more energetic manure than ordinary bone-meal. Attempts are being made to find out whether such fermentative processes are also effective in loosening the mechanical structure of pieces of bones. It has been thought worth while to find out what happens under broadly differing types of bio-chemical activities. With this end in view, various concomitant fermentative materials have been mixed with the bones, *e.g.*, cattle-dung, urine, molasses, waste curds, etc. To give body to the composts, additions of soil, sand and charcoal have also been made. Care is being taken to maintain the requisite moisture-content by adding water when necessary to make up the loss by evaporation. Periodical examinations are being made of the composts

to see how the bones are behaving. It is not yet possible to state definitely anything except that bones kept in the compost containing sand, charcoal, dung and molasses are showing some signs of yielding.

Relation between degree of fineness and the "available" phosphoric acid figure. A sample of bone-meal which was sieved into three grades of fineness—over 1·5 mm., 1·5—1·0 mm., below 1 mm.—and determinations of total and available P_2O_5 were made. The percentage availability was 1·9, 31·2 and 42·5 respectively.

The experiment was repeated with hard pieces of bone of a uniform grade retained by a 1·5 mm. sieve. This sample was broken down in an iron mortar, sifted into six grades of fineness, which were analysed for organic nitrogen, insoluble silicates and sand, total and available phosphoric acid. The results are shown in the following table :—

Substance	Dimension of particles	Organic nitrogen	Insoluble silicates and sand	Phosphoric acid	
				Total	"Available" or citrate-soluble (calculated as per cent. on total phosphoric acid)
		Per cent.	Per cent.	Per cent.	Per cent.
Original bone-meal .	Above 1·5 mm.	4·23	4·71	20·93	0·91
Original bone-meal powdered.	10—20 meshes I. M. M.	4·12	0·10	22·97	5·23
Ditto .	20—40 meshes I. M. M.	4·25	0·11	22·90	9·96
Ditto .	40—60 meshes I. M. M.	4·12	0·11	21·84	9·89
Ditto .	60—80 meshes I. M. M.	4·08	8·15	22·03	19·47
Ditto .	80—100 meshes I. M. M.	3·98	6·86	20·66	26·62
Ditto .	Finer than above	3·48	17·38	16·24	56·56

The finer fractions are poorer in organic nitrogen and in total phosphoric acid but are richer in soluble phosphoric acid.

Lime requirement of acid soils. Earlier work by Mr. Das confirmed the general experience that the same soil shows different lime requirements according to the method of determination employed. Further experiments were made with ten well-known lime requirement methods on five soils, to ascertain whether the experimental determination of residual lime requirement after a known quantity of lime was added to the soil, agreed with the calculated one. No such agreement was found, thus emphasising the fact that a lime requirement method serves only as a qualitative guide to the soil investigator.

3. Miscellaneous.

A simple method of staining bacteriological flagella. The difficulties of staining preparations of flagella, owing to their extremely delicate

nature, are well known. Procedures which suffice for the ordinary staining of bacteria are often too drastic in the case of flagella, and the latter may, in some instances, be damaged or destroyed.

A promising method of staining flagella has been worked out in this laboratory, and has given good results with all the flagellated micro-organisms so far tested.

The procedure consists essentially in first fixing the preparation with osmic acid, mordanting with a solution of vanadium tanate in tannic acid and then treating with silver solution.

The process is convenient and requires few complicated reagents. An account will shortly be published.

VI. RESEARCH PROGRAMME FOR 1931-32.

1. Alkali soil investigations.

The reclamation of soil and the maintenance of its fertility under the abnormal conditions of perennial irrigation demands a certain physico-chemical knowledge of soil characteristics, if disaster is to be avoided.

In connection with researches on alkali soil it is proposed to study the question from the following view-points—

(1) Depth distribution of soluble salts and exchangeable bases in the complete profile of alkali soils.

(2) Soil classification from the behaviour of the different acid and basic radicles in the different horizons.

(3) The study of the morphology of these soils by Gedroiz's method, *i.e.*, by ascertaining the state of disintegration in different horizons under the leaching processes in alkaline medium.

At present, the investigation will be restricted to the *kalar* area of Sind in view of the approaching completion of the perennial irrigation scheme.

2. Nitrogen balance in Indian soils.

(*a*) *General.* The analytical data from the permanent manurial plots will be completed and examined for the purpose of constructing a nitrogen balance-sheet for the different systems of manuring.

(*b*) *Biochemical.* Dr. B. K. Mukerji has just started an investigation into the relative utility of artificial fertilizers like superphosphate and sulphate of ammonia as compared with that of farmyard manure and sann-hemp which is commonly applied as green manure. For this purpose a typical soil from Indo-Gangetic area has been selected. The experiment, with different manurial treatments, is being carried in two series of pots—one carrying a crop of *marua* (*Eleusine coracana*) and the other remaining uncropped. Nitrogen changes as well as changes in bacterial number are being daily examined in the uncropped soil.

A study of the effect of these manurial treatments on the soil bacterial population is also being undertaken under the more rigorous condi-

tions of the laboratory. Since the production of carbon-dioxide serves as an index of soil fertility and is associated with the activities of the soil micro-organisms, carbon-dioxide evolution will be closely followed in these experiments.

3. The mechanism of nitrogen assimilation by rice.

Earlier work suggests that organisms capable of fixing nitrogen exist in the roots of rice. An attempt will be made to obtain these organisms in pure culture, and to trace whether any relation exists between incidence and activity of the organisms, and the various cultural conditions under which rice is grown. Preliminary investigations will also be made of other plants.

4. Manurial effect of treated bones.

Pot experiments to compare the manurial value of raw bones with bones treated as described in the report, will be carried out with different grades of fineness of bone particles, and on three soils: (*a*) acid, (*b*) highly calcareous alluvium and (*c*) non-calcareous alluvium.

5. Effect of manures on sugarcane juice.

The quality of sugarcane juice evidently affects that of the *gur*, to the production of which the major portion of Indian cane is devoted. Earlier experiment at Pusa suggested that both yield and quality, when a combination of mustard cake, superphosphate and sulphate of potash was given, exceeded those given by mustard cake with either one of the two mineral manures, but the results were not conclusive. The experiment will be repeated under more rigid conditions.

6. Curing of tobacco.

Attention will be concentrated on the effect of leaving the leaves on the stalk during curing by different processes. The 1928 experiments showed that the attack of mildews is encouraged if the stalk is retained; a further advantage of picking the leaves from the stalk is that they can be plucked at the right stage of maturity; it is, however, more costly in labour. The presence of the stalk during curing must have some effect on the cured leaf, for the reserve of water in the stalk will keep the leaf alive for a longer period in the initial stages of curing. The leaf will therefore use up more of its food supply, and may also lose some by transportation to the stalk. The quality of the leaf cured without and with the stalk will therefore be examined in detail.

7. Storage of potato.

Further study will be made of the effect of temperature on the keeping quality of the tubers, and an attempt will be made to study the process of decomposition. For the latter, measurement of oxidase and catalase activity, amino acids and the respiratory ratio CO_2/O_2 will be used.

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REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(N. V. Joshi, B.A., M.Sc., L.Ag., in charge.)

I. ADMINISTRATION.

Mr. J. H. Walton held charge of the Section till 6th April 1931, when he went on leave, and I took over.

II. TRAINING.

There was no admission of post-graduate students during the year.

A course of instruction in Dairy Bacteriology was given to five students from the Institute of Animal Husbandry and Dairying.

III. SOIL BACTERIOLOGY.

Nitrogen fixation. A further set of experiments to determine the nitrogen fixation by green algæ showed small gains of nitrogen over the control. In the two series of rotation experiments started last year to test the influence of leguminous crops on the conservation of soil nitrogen, three crops have been taken in three seasons. The figures for total nitrogen remaining in the soil at the end of two years were less than at the beginning of the experiment. This decrease may partly be due to seasonal fluctuations as was observed in many other plots. Taking into account the nitrogen removed by the crops, however, a gain in nitrogen is noticed in all the plots. The highest gain calculated in this way is 210·5 lb. per acre in one series with a mixed crop of maize and *urid* (*P. radiatus*) grown in the *kharif* (summer) season and 177 lb. per acre in the second series with *kerao* (*Pisum arvense*) grown alone in the *rabi* (winter) season. The mixed crops have given the highest economic returns, whether grown in the *kharif* or *rabi* season. As this series of experiments will be run for another two years further examination of results is not necessary at this stage.

The comparison of the value of *Crotalaria juncea* and *Crotalaria sericea* in small plots was continued. *Crotalaria sericea* did not maintain its higher yield observed in previous years, but showed a decrease on an average of 3·5 per cent. Perhaps as there was no attack of white ants the *Crotalaria juncea* plots did not suffer as in former years. This shows that the normal yield of crops manured with *Crotalaria juncea* when not attacked by white ants is higher than those manured with *Crotalaria sericea*.

As in the experimental plots of the pot culture area, the soil nitrogen in *dhab* (low-lying) area also shows seasonal fluctuations. For this reason comparison of figures of analysis made in the same month for the last three years was made, which shows that the nitrogen in this area is well maintained by the cropping system employed.

Green manures. *Urid* and soy-bean were grown as green manures and compared with sann-hemp. All these three green manures gave approximately the same or slightly differing yields of wheat grain and potatoes per acre, but the cost of sann-hemp seed on account of its high seed-rate is higher, so there is possibility of *urid* and soy-bean proving more economical green manures in practice. *Urid* is being tested on a larger scale this year and compared with sann-hemp as green manure.

Mexican sunflower was planted in a small plot in February this year to use it as green manure without having to waste any season or land for growing it, as the plot of land in which the cuttings of sunflower were planted was already growing onions crop under irrigation. The plot was very small, $6' \times 5'$ only, but the results show that if grown on a large scale, besides getting 66 maunds onions per acre, 2,069 maunds of sunflower also can be obtained for use as green manure. This would suffice to manure four to five acres of land. Tops of this sunflower when applied as green manure compared favourably with sann-hemp, weight for weight. The yield of wheat grown after sunflower was 11 per cent. higher than that obtained by the application of sann-hemp.

Nitrification. Oil-cakes are recommended to be used as manures. These pressed by the country mills contain varying amounts of oil. If present in excessive quantities the oil may prove harmful and detract from the value of the cakes as a manure. Experiments on nitrification of crushed *til* (*Sesamum indicum*) seed, extracted of its oil to different extents, were carried out in Pusa and Kalianpur soils. In Pusa soils the nitrate accumulation was lowered by the presence of the oil to a slight extent, being only 10 per cent. less than the control. All samples containing oil from 4 to 15 per cent. gave the same decrease in nitrates. In the Kalianpur soil the amount of nitrogen nitrified in the presence of 4 per cent. oil was 15 per cent. lower than in the control; but with higher quantities, *viz.*, 12 per cent. and 15 per cent. of oil, the amount was lowered by 32 per cent. This difference in the effect of the oil in the two soils is attributed to the difference in the lime content, 30-40 per cent. in Pusa soil and less than 2 per cent. in the Kalianpur soil.

A sample of soil from Phubsering tea garden, Darjeeling, was received to find out whether cyanamide used as manure in the soil would nitrify. It was acid in reaction, the pH being 5·02, but it was rich in organic matter and already contained 0·194 per cent. nitrogen. Comparison of additions of *sarson* (*B. campestris*) cake, ammonium sulphate and cyanamide to this soil showed that nitrogen in cyanamide was nitrified to the extent of 70-75 per cent., while of the *sarson* cake only 50 per cent. nitrogen and of ammonium sulphate 43 per cent. nitrogen was nitrified, showing that the lime in cyanamide resulting from the decomposition of cyanamide had helped to neutralise partly the original acidity of the soil and thus to increase the activity of the nitrifying organisms.

Influence of aluminium hydroxide and aluminium sulphate in a concentration equivalent to 0·025 per cent. and 0·1 per cent. aluminium was tested in Jorhat, an acid soil, and in Pusa soil which contains large

quantities of lime. In the latter even the highest concentration equivalent to 0·1 per cent. aluminium, whether as aluminium hydroxide or sulphate, had no effect, but in the acid Jorhat soil the amount of nitrate was lowered to the extent of 50 per cent. in all the concentrations of aluminium hydroxide and aluminium sulphate practically suppressed nitrification. The addition of 0·2 per cent. $CaCO_3$ along with aluminium hydroxide neutralized the retarding effect of aluminium hydroxide and normal nitrification proceeded, but in the case of aluminium sulpahte this quantity of $CaCO_3$ had no such ameliorating effect. It is inferred from this that the acid radicle of the aluminium sulphate has more drastic effect on nitrification than the aluminium radicle.

A study of the effect of single alkali salts on nitrification, which was completed, showed that the concentrations necessary to inhibit the nitrification were much higher than those recorded for American soils. With a view to see how far these results apply to alkali soils containing mixtures of these salts, two samples of *bara* soil from the Punjab and a *reh* soil collected locally were studied. It was found that in one *bara* soil the whole of nitrogen as ammonium sulphate and 80 per cent. of the organic nitrogen in cake was nitrified in eight weeks, while in the other nearly 60 per cent. of the nitrogen in cake was nitrified.

In the *reh* soil nitrification of ammonium sulphate was not affected by the salts, 80 to 90 per cent. of nitrogen being nitrified in eight weeks, but in the case of oil-cake, only 30-40 per cent. nitrogen was nitrified. The concentration of sodium sulphate in the *reh* soils was 0·449 per cent. in the first three inches and 0·271 per cent. in the first six inches, while sodium chloride was present to the extent of 0·047 and 0·035 per cent. respectively. In *bara* soil sodium sulphate was less than 0·034 per cent. and sodium chloride less than 0·041 per cent., but 0·03 to 0·06 per cent. sodium bicarbonate was present in these soils. In the local *reh* soils sodium bicarbonate was not noticeably present.

Bacteriological analysis of soil under irrigation and under dry farming was carried out. Samples were taken at different depths down to 36″. Samples were taken twice, once in February and again in June.

In ammonification of peptone, nitrification of ammonium sulphate and nitrogen fixation in Ashby's mannite solution, there was little difference between the samples of soils from irrigated and unirrigated plots. The number of organisms and the total nitrogen was found to be lower in June than in February in both the irrigated and unirrigated plots. In irrigated plots the decrease in nitrogen was slightly less than in the unirrigated plots. It is too early to expect any definite results from this investigation.

IV. BACTERIOPHAGY.

Root nodules from different legumes were examined for the presence of a bacteriolytic principle capable of dissolving the suspension of

cultures and nodule organisms. Several media were used but the one best suited for the purpose had the following composition :—

Mannite	2·0	
K_2HPO_4	0·5	The medium was adjusted to pH 7·8 to 8·0.
$MgSO_4$	0·2	
KNO_3	0·2	$CaCO_3$ was added separately in tubes at the rate of 1 mg. per 10 c.c. medium.
Yeast extract or Marmite	2·0	
Water	1,000	

Several leguminous plants showed the presence of bacteriolytic principles in their root nodules. Those from the root nodules of *Trifolium alexandrinum*, *Lathyrus odoratus* and *Dolichos* sp. were isolated and studied in more detail. The lytic principles after two or three passages dissolved the cultures of nodule organisms in a liquid medium. The nodule organisms were then plated out on agar with the lytic principle added, control plates of the same culture without the lytic principles being plated out at the same time. Formation of small plaques in plates with the lytic principles was observed after 24 to 48 hours' growth, proving that the lytic principles were true bacteriophages. The plaques observed were of two types. The plaques of the bacteriophage derived from the root nodule of *Dolichos* species were similar to those developing from the Shiga bacteriophage : regular small circles where no growth of the organism is observed. The bacteriophages from *Lathyrus odoratus* and *Trifolium alexandrinum* showed a central plaque or a clear space free from any growth of the organism, surrounded by a flat growth looking like a bluish halo round the plaque, this halo in its turn being surrounded by the normal pearly white raised slimy growth of the nodule organism. After a few days the halo increased in size and the slimy growth on the plate was completely transformed into a bluish flat growth in which the original clear plaques could be easily distinguished. Whether these two kinds of plaques described above result from the action of two distinct kinds of phages or are the manifestations of different degrees of virulence of only one kind of bacteriophage is a question that naturally arises out of these observations. One of these plaques with the bluish halo around it with slimy growth beyond it resembles what is called the " Twort phenomenon," except that the transformation of the growth surrounding the plaque in the Twort phenomenon is said to be vitreous instead of the bluish halo like transformation observed in the experiments ; while the other represents the true plaque caused by the bacteriophage observed by D'Herelle. There is much controversy as to whether the Twort phenomenon and D'Herelle's plaque phenomenon are different or identical. So long as the bacteriophages investigated were chiefly those attacking different disease germs, it was difficult to settle the controversy. Use of the root nodule organisms, of which there are many strains or species very much alike, affords more hope of solving the question whether the two kinds of plaques are due to the action of two agents or of one, by cross-inoculation of the different phages on the cultures of the different strains of organisms. For if two different agents are responsible for the two kinds, they would continue to produce the same kind of plaque irrespective of the strain of organism

attacked by them. As a result of repeated cross-inoculation experiments, however, it was found that the kind of plaques produced did not depend on the nature or origin of the phage but varied with the kind of organism with which the phage was grown. The *Trifolium* and *Lathyrus* phages produced plaques similar to those of the *Dolichos* phage when grown with the *Dolichos* organism, and the *Dolichos* phage when grown with *Trifolium* and *Lathyrus* organisms produced the phages surrounded by the bluish halo. It was also observed that the phages from different organisms when inoculated on colonies of organisms produced the same kind of change in the appearance of the colonies. When the growth was not slimy there was no significant change, but when the growth was slimy, raised, glistening pearly white, it was transformed into a non-slimy, flat, pale bluish one. This transformation usually began from the point of touching, in irregular zones or concentric rings from periphery towards centre. No plaques were observed in the colonies so touched with bacteriophage. Incidentally from the appearance of the colonies and of the bacterial plates after the action of the bacteriophages it appears possible that some if not all bacteriophages possess the property of decomposing the slime produced by the bacteria. Probably bacteriophage is able to secrete an enzyme which may be termed " pentosanase " or " pectinase " according to the nature of the slime. This property is independent of its power of destroying the bacteria.

From these cross-inoculation experiments of phages on different nodule organisms the conclusion may be drawn that the two kinds of plaques are not caused by different agents but are manifestations of one and the same cause, whose action appears to vary with the kind of growth attacked. It is not to be understood that bacteriophages attacking different organisms are one and the same. They may be different and some quite specific for particular organisms, but what it is intended to suggest is that when working with bacteriophages the " Twort phenomenon " will be observed if the growth of the organism is slimy, while in the case of the non-slimy culture only the clear plaques or " D'Herelle phenomenon " will be observed.

The virulence of the bacteriophages was enhanced by successive passages at the expense of the organisms. Maximum virulence attained so far in the above-mentioned medium was 1×10^{-7}. Increase in the percentage of sugar to 0·5 per cent. in the medium after isolating the bacteriophage was found to increase the virulence to 1×10^{-10} in the case of *Dolichos* phage.

The rate of lytic action of the phage was rapid. Thirty-eight millions of organisms per c.c. were reduced to only 1,000 per c.c. in 24 hours.

The secondary cultures were found to develop after the dissolution of the organisms by the phages. When streaked on agar, the secondary culture, mixed as it is with the phage, gives a meagre dry opaque growth. Long continued contact with phage renders the growth non-slimy, translucent, bluish with a tinge of yellow in it. The secondary cultures lose

their resistance to the bacteriophage if separated early from the phage and cultivated in its absence. Long continued contact with the phage renders it difficult to free the culture from the phage. The bacteriophages dissolved all the strains of the organisms after their virulence was sufficiently increased.

In the course of the bacteriophage experiments it was observed that too much slime production retarded the action of the phage, and the root nodule organisms had to be grown on special media with a view to eliminate the slime. The slime also renders it difficult to stain the flagella of the organisms. For these reasons an attempt was made to find a suitable medium to eliminate the slime production. Additions of peptone or nitrate nitrogen or ammonium salts to the medium were found to decrease the slime production of the organisms studied so far.

As the action of bacteriophage altered the character of the growth of the organisms, a comparative study of the biochemical reactions and cultural characteristics of the root nodule organisms with and without the phage was started. It will take some time to arrive at any definite conclusions.

V. DAIRY BACTERIOLOGY.

The average plate counts of the bacterial content of milk supply are given below with those of the previous two years for comparison.

Month	Average count per c.c.			Coli counts 1930-31		
	1928-29	1929-30	1930-31	Days present in 1/100 c.c.	Days absent in 1/100 c.c.	Days absent in 1/10 c.c.
July	17,300	18,800	5,500	1	13	10
August	22,250	13,300	4,400	*Nil*	12	8
September	22,150	17,140	6,700	*Nil*	12	4
October	17,000	11,400	2,840	*Nil*	12	12
November	12,600	8,200	5,400	*Nil*	12	12
December	12,000	5,500	1,840	*Nil*	9	9
January	9,400	5,980	2,200	*Nil*	15	15
February	9,900	5,700	2,900	*Nil*	12	10
March	8,800	12,800	3,565	*Nil*	14	6
April	15,460	40,000	3,472	6	6	4
May	19,800	61,200	3,900	3	11	7
June	12,600	5,660	2,664	1	13	10

The counts for the year were the lowest recorded at Pusa.

This result is in part due to the changes in hours of milking and distribution. In previous years the milk was kept in the shed for two to three hours. Since June 1930, it is distributed within an hour of milking. As a result the milk that is distributed is of a very high grade. This improvement is further seen by the absence of *B. coli* for eight

months and its presence only on 11 days out of 149 days in 1/100 c.c. In September 1930, the highest monthly average count of the year was recorded. It is only 6,700 per c.c. which is far below the average count of 30,000 per c.c. allowed in certified milk.

Samples of milk stored at 10°C. in the Frigidaire kept good for one week throughout the year except in June when they kept good for six days only.

Plate counts were made from the middle milk of 40 Montgomery cows ; only six cows showed counts of over 10,000 per c.c. All the six cows had given high counts in previous years.

It is generally found that the milk samples stored in the refrigerator show a decrease in counts after 24 hours, during the period between October and February. This decrease is attributed to bactericidal property of fresh milk affecting certain kinds of bacteria. In other months the bactericidal power is counteracted, as a result of the prevailing high temperatures, by the increase in numbers of bacteria that are not affected by the germicidal agent present in milk.

Investigations of the types of colon bacilli present in milk were continued. The conclusions arrived at confirmed those of the previous year. A paper on the subject was submitted for publication.

A study of the lactic acid organisms isolated from *dahi* (curdled milk), which is an article of food with many in India and is used as a starter for butter, showed that these organisms, when grown successively in pure cultures, grew sluggish in their action after some transfers and failed to coagulate milk. The milk thus previously inoculated with the sluggish strain remained sometimes uncoagulated even when an addition of an inoculum from a new and vigorous strain was made. Also the pure cultures of lactic acid organisms were found to die within a short time : 8 or 10 days. This was not in all cases due to acidity developed by the culture, because the lactic organisms grown in dilute whey to which peptone was added also behaved in the same way. In this medium even with very little acidity developed by the organisms the pure cultures could not survive for more than 5 or 6 days. Filtrates of the dead cultures of the organisms in milk did not show the presence of any inhibiting agent. Whatever the real cause of these observations may be, it appears to be removed or counteracted by the presence of a torula which is usually found associated with the organism in the curds, the *dahi* of the Indians, since it was observed several times that lactic organisms were alive in a mixed culture with the torula even when the mixed culture was more than six months old. To find out whether the action of the torula is exerted through some soluble products produced by it, an extract of the cultures of torula killed by chloroform was used as an additional nutrient in milk used for growing the lactic organisms. This addition of extract of torula culture had the effect of extending the life of the lactic cultures to about three weeks instead of 10 days. Substitution of an autoclaved extract of dry yeast of Cerevesæ type in place of the torula extract also extended the life of the lactic organisms

in pure culture to about twenty days. So a Cerevesæ type of yeast was grown in a mixed culture with the lactic organisms instead of the torula to see whether it is able to lengthen the life of cultures of lactic organisms, and this mixed culture has lived for more than a month. The torula cultures were found to reduce to some extent the acidity developed by the lactic organisms and may be a factor in extending the life of the culture of the lactic organisms, but the extract of chloroformed torula cultures and the autoclaved extract of dried yeast did not reduce the acidity of the lactic organisms, nor did the Cerevesæ type of yeast have any great effect on the acidity of mixed cultures. So it is probable that the yeast and torula may be acting as a constant source of vitamin to the lactic acid organism in the mixed culture. This constant supply of vitamins may be the principal factor in lengthening the life of the lactic acid organism in mixed cultures.

VI. DISINFECTION EXPERIMENTS WITH PERCHLORON AND CATADYN PELLETS.

Perchloron is a chlorine compound containing about 65 to 70 per cent. available chlorine. Compared to bleaching powder it absorbs less moisture from the air. Tests were carried out to determine its efficiency. Its germicidal power in solution was equal to that of E. C. or bleaching powder solution containing the same amount of available chlorine. One oz. of perchloron added to 16 gallons of water acidified with one ounce of citric acid was quite effective in killing refractory spores of organisms like *B. subtilis* and *B. albolactus*.

The time of contact necessary for the purpose was 15 minutes even in the presence of organic matter like cowdung.

Stability of perchloron was tested by keeping it in a drum with a closed cover and a stoppered bottle. A sample which contained 65·5 per cent. available chlorine in October had 62·2 per cent. at the end of April, and at the end of June it contained 56·3 per cent. showing a further loss of 10 per cent. available chlorine. The total loss in the closed drum after eight months' storage at room temperature was 15 per cent. of its original content. A sample of bleaching powder kept in an open drum of original content 31 per cent. available chlorine at the end of April contained at the end of June only 13·1 per cent., showing a loss of 60 per cent. available chlorine in two months; a sample in a stoppered bottle showed a loss of 27 per cent. only during the same period, its content of available chlorine being 30 per cent. at the beginning, and 22 per cent. at the end of the experiment. The greater loss in the months of April and June in all these cases is no doubt due to the high temperature (27°C. to 32°C.) prevailing in the laboratory. At a lower temperature, 10°C. approximately, the loss was found to be about 5 per cent. only in the bleaching powder kept in a stoppered bottle.

Sterilization of water by catadyn pellets. A series of experiments were carried out to test the efficacy of catadyn pellets as a sterilizing agent. These pellets are stated to consist of some inert material like unglazed

porcelain on which is precipitated a thin spongy coating of silver produced by a special process. It is also stated that water is not only rendered sterile by contact with the pellets but that the water acquires in addition germicidal properties. It was found that the best way of obtaining water, for experiments to test these statements, was to place the pellets in a funnel through which water is passed at the rate of one litre in three minutes. River water passed through the catadyn pellets in this way showed a considerable reduction of bacteria, only the spore-formers surviving. Probably the vegetative cells of the spore-formers may be killed by catadyn water but the spores are unaffected. To confirm this result emulsions of pure cultures of a spore-former and a non-spore-former were passed separately over the pellets and the filtrate plated out on nutrient agar to see the number of organisms surviving. The results are shown in the following table :—

Organism.	Number present initially	Number in the filtrate after standing one hour
B. coli	66,000	*Nil*
B. subtilis old culture	6,300	5,000

To test whether the water passed through catadyn pellets acquires germicidal properties, tap water passed through catadyn pellets was added to an equal quantity of an emulsion of *B. coli*. The mixture initially contained 77,000 organisms per c.c. The number of organisms after one hour's standing of the mixture was found to be 27 per c.c. This germicidal effect of water passed through catadyn pellets in the above experiment is likely to be of use in dairies, for sterilization of milk bottles for which purpose steam is used at present. Catadyn water can probably replace steam and reduce the cost of cleaning the bottles. A number of bottles in which milk had soured were washed with soda and brush in tap water to remove fat. This procedure is necessary as the presence of fat in bottles interferes with the removal of bacteria. The bottles were divided into two lots. One lot was filled with catadyn water, the other was kept moist to imitate rainy season conditions. Bacterial counts were made from the washings of the bottles after four hours and sixteen hours. In the catadyn water set the water contained in the bottles was emptied immediately before the addition of sterile water.

Treatment	Bacteria per c.c.	
	After 4 hours	After 16 hours
Bottles kept moist over a basin of water . .	103	1,700
Bottles filled with catadyn water and emptied .	3	22

The continued presence of moisture in the bottles had the effect of increasing the number of bacteria in the bottles, but the catadyn water was found to check their growth and prevent their multiplication.

VII. SILAGE.

Following a suggestion of this Section, a silage pit was filled on the farm in March 1931 with berseem and green oats. The silage pit was opened in June 1931 and examined. The colour and smell showed a decided improvement over silage from berseem alone; lactic acid organisms were present, the pH was found to be 5·43 and total acidity showed an increase, 5·4 per cent. on dry matter as against 3·96 per cent. found in silage produced from berseem alone.

VIII. ACETIC FERMENTATION.

It was found that plantain fruits which are not saleable on account of their being over-ripe and giving an odour of esters could be used to produce vinegar of good quality. The acidity at the end of the experiment was 6·7 per cent. acetic acid. Over-ripe jack fruit could also be similarly used. They gave an acidity of 6 per cent.

IX. PRESERVATION OF VEGETABLES.

The preservative value of *ajwain* (*Carum copticum*), *souf* (*Foeniculum vulgare*) and mustard (from Bombay Presidency) in the preparation of mango pickles was studied. Of these, *souf* at the concentration of 5 per cent. of the mango was found to prevent the growth of fungi for 8 to 10 days. Mustard at the same concentration prevents the fungal growth from appearing for more than a fortnight.

Potato storage. Experiments on potato storage showed that potatoes harvested earlier (February 14th) than is customary in these parts keep better than those harvested later (March). Cinders and charcoal again proved the best materials for storing potatoes.

X. PLANT DISEASES.

Khira (*Cucumis sativus*). A leaf spot of *khira* which is of common occurrence in these parts was found in the Kitchen Garden. This disease was found to be due to *Bacterium cucurbitæ* (Bryan). The results were published.

Turnip. A white rot of turnip was first observed at Pusa this year. The rot was due to an organism very similar to *Bacillus aroidæ* (Townsend). The results were sent for publication.

Canna. Diseased specimens of leaves and buds of canna received from the Dooars were studied and the disease was reproduced by inoculation. The organism was found to be *Bacterium cannæ* (Bryan).

XI. PROGRAMME OF WORK FOR 1931-32.

Conservation of nitrogen in soil. Conservation of nitrogen is one of the important problems in maintaining the fertility of Indian soils, and growing of leguminous crops in mixtures or rotation is one possible method. A series of field experiments have been started, one adapted to the *kharif* season and the other to the *rabi* season. The variations in total nitrogen in the soil and the economic returns of crops will be examined.

Green-manuring is another method of supplying nitrogen. The use of sann-hemp as green manure is hindered owing to the loss of one season in growing the crop before its use and by the high cost of seed.

Large-scale experiments will be made with *urid* and soy-bean whose seed is cheaper, while the possibility of using sann-hemp both as a fibre crop and as green manure by postponing the application of the latter by a month will be tried against the normal method.

The experiment with Mexican sunflower mentioned in this report will be repeated on a larger scale.

Biological analysis of soils. Study of biological analysis of a soil, especially its rate of ammonification and nitrification, gives a definite idea of its fertility or discloses any defects that require to be remedied to attain normal fertility. Such analyses of different soil will be carried out as occasion arises.

Calcium cyanamide has been found to nitrify in certain soils while it has failed to show nitrification in others. The reason for this is not yet definitely known. As the nitrification depends upon the decomposition products of cyanamide formed in the soils, these will be studied in the soils which do not show nitrification of cyanamide.

Bacteriophagy. The experiments with bacteriophages of root nodule organisms reported this year have opened out a fresh field for research. Isolation and study of bacteriophages from different legumes will be continued with special reference to the effect of the bacteriophage on nodule formation in these plants. The changes in cultural characteristics and biochemical reactions of the root nodule organisms as induced by the presence of bacteriophage in the culture will continue to be studied.

A search for bacteriophages of root nodule organisms will be made in non-leguminous crops, especially from roots of plants like maize, rice, oats and wheat. It is suspected that bacteriophage may have some connection with the fact already noted in this laboratory that graminaceous plants directly derive a certain amount of benefit from the cultures of the root nodule organisms.

Dairy Bacteriology. Quantitative study of bacteria present in the general milk supply at Pusa at the time of distribution and in the individual cows with a view to bacterial control of cleanliness in production of milk in the dairy.

Study of types of *coli* organisms present in milk will be continued, also the utilisation of catadyn as sterilizer of water and its application to dairy practice.

Study of lactic organisms in *dahi* and the influence of yeast on their vigour will be continued.

Bacteriology of silage. It has been found in the laboratory and by practical experiments that all crops put into the silage pit do not produce equally good silage. It is proposed to find out the crops suitable to mix with each other, so as to supply a suitable medium for the silage bacteria to act, and the proportions in which to mix them.

Other investigations. Study of the preservation of fruits and vegetables by cold storage and effect of spices in pickles in preventing spoilage will be continued.

Observation and investigations of bacterial diseases of plants as they occur.

XII. PUBLICATIONS.

WALTON, J. H., AND BISWAS, S. C.	The Sterilization of Milk for use as a Culture Medium. *Jour. Central Bur. for Animal Husbandry and Dairying*, Vol. IV, Part IV, December 1930.
WALTON, J. H. . .	The Influence of Alkali Salts on Nitrification in some Indian Soils. *Ind. J. Agri. Sci.*, Vol. I, Part IV, August 1931.
	The Colon Bacteria occurring in the Milk Supply at Pusa. *Ind. J. Vet. Sci. and Ani. Hus.*, Vol. I, Part III, September 1931.
HARI HAR PRASAD . .	A Note on Bacterial Leafspot of *Khira* (*Cucumis sativus*). *Ind. J. Agri. Sci.*, Vol. I, Part II, April 1931.
	A Bacterial White Soft Rot of Turnip. *Ind. J. Agri. Sci.*, Vol. I, Part V, October 1931.
VYAS, N. D. . . .	Storage of Potatoes. *Agri. Jour. of India*, Vol. XXV, Part V, September 1930.
	Study of the losses of Fertilizing Constituents from Cattle Dung during Storage and a method for their Control. *Agri. and Live-stock in India*, Vol. I, Part I, January 1931.

REPORT OF THE IMPERIAL MYCOLOGIST.

(W. McRae, M.A., D.Sc., F.L.S.)

I. CHARGE.

On his return from leave on the 8th December 1930, Dr. McRae took over charge of the Section from Dr. M. Mitra.

II. TRAINING.

Mr. P. R. Mehta, B.Sc., completed his post-graduate training and continued his work for the next three and a half months. Mr. U. B. Singh, M.Sc., continued his post-graduate studies, and Mr. B. S. Das, M.Sc., was admitted to the course. One student left on the award of a State scholarship to study plant physiology in England. Five students from the Imperial Institute of Animal Husbandry and Dairying, Bangalore, received a short course on diseases of fodder crops during January. Mr. K. M. Desai, Assistant to the Mycologist, Poona, worked in the Section in September in connection with his study of *Sclerospora*.

III. DISEASES OF PLANTS.

(1) Pigeon-pea.

Fusarium vasinfectum on *Cajanus indicus*. In collaboration with the Imperial Economic Botanist the investigation on the isolation of a wilt-resistant type of *rahar* was continued. The wilt-resistant capacity of one type is again confirmed. In an infected field T. 1 and A. 2 (W. R.) were sown in alternate rows. Of 198 plants of the former, 147 wilted or 74 per cent., while of 209 plants of the latter, only 2 plants wilted or 1 per cent.

Fifteen rows of 42 plants in each row of type T. 1 and type A. 4 were sown in alternate rows in each of six highly infected quarter-acre plots in D Block of the Punjab Field.

Plot	Type T. 1			Type A. 4		
	No. of plants	No. of wilts	Per cent.	No. of plants	No. of wilts	Per cent.
10D . .	629	583	93	626	19	3·0
11D . .	628	499	80	622	7	1·1
25D . .	628	309	49	620	5	0·8
26D . .	628	213	34	626	3	0·5
27D . .	626	436	70	616	9	1·4
28D . .	627	342	54	623	27	4·3
Mean per plot .	627	397	63	622	11·7	1·8

All six plots were highly infected as measured by the number of wilts in Type T. 1 while Type A. 4 has shown a high degree of resistance.

On the Pusa farm in Chonia field of 27 acres, which is in the regular three-year six-course rotation with *rahar* occurring once in three years, there were 20 per cent. of wilted plants and in one patch of about an acre the percentage went as high as 55. In Jhilli field, where no regular rotation is followed, and *rahar* has not been grown for eight years, eleven acres of six farm selections and nine acres of A. 4 had no wilted plants. Formerly we had experience that the wilt fungus did not survive in the soil for ten or more years ; now this year the known interval has been reduced to eight years.

In cultivators' fields in the vicinity of Pusa samples of forty-three fields were taken by counting the plants on two or four adjacent rows. In all 41,262 plants were counted, of which 2,566 were wilted or 6·2 per cent. As invariably some wilted plants have been removed for fuel during the season, this is an underestimate of the total amount of wilt, though this was reduced as much as possible by taking fields at some distance from the villages.

The experiment to determine the effect of superphosphate on the development of the root-system of *rahar* as described in the report for 1929-30 was repeated. The roots were washed out after three months of good growth. The number of branches from the tap root was almost twice as great and the number of subsidiary roots was many times greater in the layers which had superphosphate, and this abundance extended to the next six inches below the superphosphate layer. It is now established by this and previous work that superphosphate causes both the *rahar* roots and the wilt fungus to grow more vigorously.

Partial sterility of rahar branches. Seeds from the previous year's crop grown from seed of plants with partial sterility were again sown but no difference was observed either in growth characters or yield between these plants and healthy plants of Pusa C variety. Leaf juice from four farm selections showing partial sterility was injected into four groups of fifty healthy young plants but none of the 200 plants were affected. Apparently the seed of plants with this partial sterility produces healthy plants in two successive seasons. Injection of juice will have to be tried again before a safe conclusion can be drawn regarding its transmissibility.

A *Colletotrichum* attacking twigs of *Cajanus indicus* in Pusa agrees with *Colletotrichum cajani* Rangel and in culture produces the ascigerous stage which agrees in general characters with *Glomerella cingulata.*

Mr. Udai Bhan Singh, post-graduate student, has studied a leaf-spot disease of *rahar* caused by a species of *Cercospora* and one of *Dolichos lablab* caused by *Cercospora Dolichi* E. and E.

Cercospora n. species. Two strains, that differ in cultural characters, one from Allahabad, the other from Pusa, have been found to be parasitic on leaves and petioles of *Cajanus indicus.* So far infection has been brought about by the conidia only. The fungus has been studied under

various conditions of temperature, humidity, food-material, light and hydrogen ion concentration. Growth occurs between 6°C. and 37°C. with the optimum between 27°C. and 28°C. and is least in continuous light, more in continuous darkness and most in alternate light and darkness. It is best at 100 per cent. humidity but occurs from 47 per cent. The range of hydrogen ion concentration as tested on adjusted modified Richards' solution extends from pH 2 to pH 9·7 with the optimum at pH 6·7, and all concentrations are reduced to about pH 2·9 after 45 days' growth.

Dolichos lablab. Cercospora Dolichi E. and E. is a virulent parasite attacking all aerial parts of the plant. The fungus has been studied under various conditions. Growth occurs between 6°C. and 40°C. with the optimum at 25°C. except on Richards' solution agar when it was 27·5°C. It is greatest at 79 per cent. humidity and occurs between 47 and 100 per cent. The range of hydrogen ion concentration on adjusted modified Richards' solution is from 3·3 to 8·1 with the optimum at 7·1. and all concentrations are reduced to 2·3 after twenty days' growth. A number of sectors have appeared in culture, two of which differ markedly from the parent in the colour of the aerial and submerged mycelium, linear rate of growth, sporulation and pathogenicity. Infection is brought about readily with mycelium and with conidia. Cross-inoculation has shown that this fungus can infect *Cajanus indicus*.

(2) Sugarcane.

Mosaic disease. In addition to the varieties mentioned in previous reports, Co. 302 was found infected in Pusa. This variety was free from the disease during the last three years. The Cane-breeding Station at Coimbatore and the Dairy Farm at Karnal remained free from mosaic. No report was received from the provinces about its appearance on new varieties.

The whole area of forty-two acres under sugarcane on the farm was rogued. In 1·9 acre of Co. 205 there were 215 clumps of mosaic-infected cane or 0·7 per cent., while in two small plots, 9·02 and 0·14 acre, there were 58 and 15 clumps or 2·8 and 6·2 per cent.

In 8·2 acres of Co. 213 there was	1 clump	infected or	0·001	per cent.
In 0·6 acre of Co. 299	„ were 2 clumps	„	0·02	„
In 0·6 „ of Co. 302	„ „ 7 „	„	0·08	„
In 1·25 „ of Co. 303	„ was 1 clump	„	0·005	„

The other twenty-nine Coimbatore varieties and TUC 393, TUC 472, POJ 2871, POJ 2878 and POJ 2696 were free. The average infection on Co. 205 is 0·8 per cent., while the average on the rest of the area is 0·002 per cent. In previous observation in 1927 it has been found that Co. 205 shows the mottling of the leaves late and that the mottling disappears early. For this reason roguing has not been successful in reducing the disease to a negligible amount. Because of its high fibrous content Co. 205 has fallen into disrepute with the mills and is now being discarded and Co. 285 is taking its place. Roguing for five years has reduced the infection on the other varieties to a very small amount,

eleven clumps in forty acres. The seven clumps in Co. 302 are likely to have come from a single plant of the previous season that was infected late and did not show symptoms at the time of planting. This explanation, however, does not fit the other four isolated infected clumps. They are possibly due to late infection in which the virus got only a short distance down the stem so that only one infected set was cut from that stem.

In the test for the natural spread of mosaic where a row of each of twenty-five varieties is alternated with a row of mosaic-infected cane, the old canes were ratooned but no disease appeared in any of the test rows. This experiment was laid down again in March this year and instead of Co. 219, Co. 237, Co. 243, Co. 244, Co. 248, Co. 275 and Co. 287 the following were substituted Co. 298, Co. 304, Co. 310, Co. 312, Co. 313, Co. 315 and Co. 316 but so far the symptoms have not appeared.

Tonnage experiment. Ten pairs of mosaic and mosaic-free plots of Co. 213 and eight pairs of Co. 205 were grown. A slight amount of infection spread to the mosaic-free plots but it was too small to make any appreciable difference in the yield and it was this fact that made possible the plan of the layout of the experiments. After removing cane to eliminate edge effect the plots of Co. 213 were seven by fifty yards and of Co. 205 four by forty yards and the yield in maunds (82·28 lb.) of stripped cane was as follows :—

Co. 213		Co. 205	
Mosaic-free	Mosaic	Mosaic-free	Mosaic
58·7	55·5	9·10	9·03
56·9	52·4	9·12	7·88
46·8	49·7	9·03	8·11
42·6	45·4	8·06	6·93
48·2	42·8	7·96	7·27
46·2	45·9	7·92	7·61
42·5	39·6	7·88	7·09
42·9	42·7	9·24	8·44
53·2	43·6		
50·0	47·9		
Mean 48·80	46·55	Mean 8·53	7·79
Difference 2·25 mds. or 4·6 per cent.		0·74 md. or 8·6 per cent.	

	Mean difference	Standard Deviation	Mean Diff. / St. Dev.	Odds
Co. 213	2·25	3·61	0·62	20
Co. 205	0·74	0·37	2·0	Very great

The odds against the difference in Co. 213 being a fortuitous difference are 20 to 1 and in Co. 205 very great, so it may be safely concluded that in Pusa the mosaic disease has lowered the weight yield of stripped cane by a small percentage.

Samples from all plots were analysed by the Imperial Agricultural Chemist and the mean weights are as follows :—

Cane	Weight of cane in lb.	Weight of juice in lb.	Percentage weight of juice to cane	Brix corrected	Sucrose %	Glucose %	Purity %
Co. 213—							
Mosaic-free .	36·375	22·285	62·823	16·472	14·887	0·499	90·256
Mosaic. .	33·950	21·275	62·665	15·658	13·901	0·557	88·699
Co. 205—							
Mosaic-free .	15·33	8·54	55·83	18·22	15·95	0·54	87·58
Mosaic. .	15·41	8·74	57·54	18·32	15·98	0·58	87·25

From the analysis of Co. 213 it will be seen that the Brix reading, sucrose and the purity are reduced while the glucose content is slightly increased. Even though the lowering of the purity and the increase in glucose ratio are small, still such a reduction in purity is an important factor for the manufacturer and, for a factory working a crop of fifteen lakhs of maunds of cane in a season, would represent a loss to the mill of approximately Rs. 20,000 for the season.

The statistical figures calculated by " Student's " method are summarised for Co. 213, while those for Co. 205 are omitted as the differences were found on calculation not to be statistically significant.

Co. 213	Mean difference	Standard Deviation	Mean Diff. / St. Dev.	Odds
Juice in sample . . .	1·6	1·79	0·9	81
Brix	0·81	0·52	1·5	1,428
Sucrose	0·99	0·77	1·8	555
Glucose	0·058	0·116	0·5	11
Purity	1·56	2·26	0·69	28

The experiment shows that in Pusa in the conditions existing in the season 1930-31 the loss of tonnage was small in Co. 205 and Co. 213, and that the lowering of the quality of the juice was small in Co. 213 but did not show in Co. 205.

Top rot. Scattered cases of this disease were found and a species of *Fusarium* resembling *Fusarium moniliforme* was isolated. Infection

experiments show that the fungus is parasitic. In moist conditions it produced a reddish brown discolouration on the stem at the place of infection but it did not produce the rot of the region of the growing point and shortening of the leaves. Further studies are being continued to discover the conditions under which the disease can be produced.

Sclerospora sacchari. No fresh case has been found in the field since the single case found by Fieldman Sahaya during the roguing of the cane last year. Sugarcane, *Setaria italica*, *Sorghum vulgare*, *Pennisetum typhoideum*, *Eleusine coracana*, *Euchlaena luxurians* and *Zea Mays* were inoculated but so far only the last two have become infected. Four plants raised from setts of last year's infected cane which was found in May showed the disease in June 1931.

Helminthosporium. Three new species of *Helminthosporium* have been described from Cuba on sugarcane forming leaf-spots, and all these are supposed to be different from *H. Sacchari* Butl. occurring in India. The eye spot disease formerly known in Cuba as *H. Sacchari* has recently been changed to *H. ocellum* Fars. A comparative study of all the species from Cuba with the original *Helminthosporium* disease first described from India, *viz.*, *H. Sacchari* Butl., was started with a view to test the basis on which the recent change in nomenclature was effected. A study of *H. Sacchari* Butl. has shown that it consists of several strains and these strains have evolved in artificial cultures and have kept constant characters for the last three years. *H. Sacchari* and the other three species from Cuba are different macroscopically on different cultural media as shown by the variation in colour, amount of aerial mycelium, zonation and the linear rate of growth but such wide range of variation is also shown by *H. Sacchari* and its strains. A study of the microscopic characters of all the species is in progress and variation in spore-size and septation, colour of spores, etc., are being noted for comparison. Inoculation experiments are also being carried out to compare the various fungi under natural conditions. During the course of the study several saltants have appeared in all the species, and these are being studied to find out whether the saltants of one fungus resemble the other fungi.

Ustilago scitaminea was found in one clump of Co. 281 and in six clumps of Co. 327.

(3) Cicer arietinum.

From cases of wilt disease in Type 39 of the gram cultures grown in the Botanical Area a strain of *Fusarium* isolated in January 1930 has been found to be parasitic on the three types tried 39, 41 and 57. Six young plants were grown from seed in potato tube in Knop's solution in a water bath at 24-27°C. On the hypocotyl was placed a small piece of mycelium with spores. In from 10 to 16 days the plants wilted. Sections showed the presence of the hyphae within the tissues of the stem and from flamed pieces of the stem the fungus was reisolated. Of ten young plants in similar conditions kept at 18° to 20°C. only six took

infection. Twenty plants of each of types 39, 41 and 57 grown in pots at 24° to 27° C. became wilted from 10 to 16 days after infection, while five similar plants of each type kept as controls remained healthy. The fungus was found in the cortex and vessels and was isolated from each of the types. This investigation is being continued.

Rhizoctonia Solani and a *Sclerotium* sp. were found together in the collar and roots causing shrinking and cracking and ultimate death. Both fungi have proved to be parasitic. The latter has been sent for identification to the Imperial Institute of Mycology.

Mystrosporium leaf blight appeared in the middle of January 1931 on T. 68, by the end of February on thirteen other cultures of gram and in March on forty-seven more, but the intensity of the disease was lighter as compared with previous years, only the first named variety was severely damaged. It was found that steeping in 0·5 per cent. formalin solution killed the spores and prevented the growth of the fungus but did not affect the germination of the seed. A field experiment was carried out on seventeen cultures of gram but was a failure because of the thin stand of plants from the treated seed due to some undetected mistake in the treatment.

(4) Wheat.

Observations on *Tilletia indica* n. sp., the bunt reported last year, were continued. A survey of the wheat crop at Karnal belonging to the Botanical Section Sub-station, Imperial Dairy Farm and the Punjab Agricultural Farm showed that this bunt was present on a number of wheat varieties, both hybrids and their parents. The disease has been recorded on the following—P. 52 ×Fed. 20-1, P. 52 × Fed. 64-1, P. 52×Fed. 38-1, P. 4×Fed. 3-1, P. 4 ×Fed. 1-1, P. 4 ×Fed. 64-1, P. 4 × Fed. 7-1, P. 4×Fed. 97-1, P. 114, P. 117, P. 52, P. 4, Federation and Punjab 8A. It was not possible to detect infected from sound plants as in external appearance bunted wheat is not different from normal wheat plants. In order to see whether the disease is present in a certain variety, samples had to be taken from different places in a plot and the wheat grains examined after being threshed. All the grains in an ear generally are not infected and the disease at present does not seem to do much damage. The fact that its presence was noticed on Punjab 8 A showed the probability of its being present in other colder parts of the Punjab. Consequently an opportunity was taken by Dr. Mitra to examine wheat in Lahore grain market where it is stored in large quantities from different parts of the Punjab, and bunted grains were found to be fairly common. This shows that the disease is present throughout the province.

Seeds from most of the varieties on which bunt was recorded in Karnal last year were brought to Pusa and grown but no disease appeared, though seeds from the same samples produced bunted grain in Karnal. Infection experiments were further carried out in Pusa both in plots and in pots by heavily infecting seeds and seedlings with bunt spores but no infection took place. Selected diseased seeds showing slight natural

infection were also sown but no plant produced the bunt, though in some cases inoculated seedlings showed the presence of mycelium resembling that of a smut no bunted heads however appeared from plants raised from such seedlings. The disease does not appear under Pusa climatic conditions as it is perhaps unable to stand the higher temperature of Pusa during the wheat season.

Attempts were made to study the germination of spores by using different kinds of media. It was found that spores freshly obtained do not germinate but those eight or nine months old germinate though the germination was very poor. The mode of germination was as in other species of *Tilletia* known on wheat.

Spores when mature are brown to dark brown, spherical or sub-spherical, 22-42 × 25-55 μ in diameter, average 35·5 μ and mode at 36. The proliferations of the epispore are reticulate, the ridges or scales somewhat roundish or irregular showing at the circumference of spores a band about 2-4 μ in length. Mixed with spores are numerous large yellowish or sub-hyaline sterile cells, rounded or angular and smaller in size than the spores with comparatively thinner walls. These correspond in part to undeveloped spores.

This species of *Tilletia* is similar to *T. tritici* (Caries) but unlike the latter it has no greasy spore mass and no smell of rotten fish. The spore mass dries into pustules and is capable of being blown about by wind. It resembles *T. tritici* in having reticulate walls and differs from it in having much longer spores.

Helminthosporium tritici repentis Died. was far more common in Pusa than *H. Sativum* P. K. & B. As the spots formed by these two species of *Helminthosporium* are so similar that no separate estimate of the percentage of leaf area destroyed could be made, the following estimation of percentage of leaf area destroyed by both species combined on various wheat varieties grown in Pusa was worked out according to the method described by Tehon.

P. 4 20·3, P. 6 4·8, P. 12 3·2
P. 52 2·1, P. 101 1·4, P. 111 22·4
P. 115 4·3, P. 116 8·6, P. 117 15·1
P. 161 8·0, P. 162 4·6, P. 163 2·8
P. 81-31 5·6, Country 3·2.

Pusa 4 and P. 111 were found to be highly infected and P. 12, P. 52, P. 101, P. 163 and country wheat had the least infection.

Wheat rust. A survey of rust on all the varieties of wheat grown in the Botanical Area was made as in previous years. The orange rust was first observed on 20th December 1930 on Pusa 52, Pusa 12 and the country variety. The yellow rust was first observed on T. 83 (Bihar type) on 13th January 1931 and black rust on 31st January 1931 on Pusa 101. The percentage of leaf surface covered by the rust pustules was measured as in previous years (Tehon's method) and the following results were obtained :—

Variety	Orange rust	Yellow rust
P. 4	9·0	..
P. 6	0·2	Traces
P. 12	11·4	..
P. 52	1·5	0·3
P. 101	1·2	0·24
P. 111	0·6	..
P. 115	Traces	2·6
P. 116	Traces	..
P. 117	0·15	..
P. 161	4·5	8·0
P. 162	Traces	4·6
P. 163	1·3	2·8
P. 80-5	0·5	..
Country	4·2	..

Wheat cultures grown at the Botanical Section Sub-station, Karnal, were examined for rust and the average percentage of leaf area covered by orange rust ranged from 0·2—7·5 while yellow rust was from 0·4—13 per cent. on various wheat varieties. Black rust was absent or present only in traces. Pusa 115 and Pusa 52 were lightly attacked by yellow rust in Pusa but at the time of examination in Karnal Pusa 115 was so badly attacked by yellow rust that the leaves were dried up and the grain was shrivelled and useless and the grain of Pusa 52 also was badly shrivelled.

(5) Barley.

H. teres which is very rare in Pusa was present this year on a number of the barley types grown in the Botanical Area though altogether absent anywhere else in the vicinity of Pusa either in the Farm or in cultivators' plots. An estimate of the percentage of leaf-area destroyed was made according to Tehon's method of the twenty-four types grown in the Botanical Area and is shown in the table below. It will be noticed that some of the types were very badly attacked with *H. teres* such as T. 6, T. 7, T. 21. Some of these varieties, *e.g.*, T. 21, T. 17, T. 12 and T. 7 were also grown elsewhere and there was no trace of *H. teres*. This shows that *H. teres* was introduced into the Botanical Area in seed of some imported variety probably from England or Nepal.

Estimatation of the percentage of leaf-surface covered by H. teres Sace. and H. sativum P. K. & B. on barley varieties grown in Pusa during 1930-31.

Type	Attacked by		Total	Type	Attacked by		Total
	H. teres	H. Sativum			H. teres	H. Sativum	
1 . .	1·8	4·1	5·9	13 . .	7·5	0·9	8·4
2 .	..	3·0	3·0	14 . .	7·1	1·1	8·2
3 . .	1·2	1·2	2·4	15 . .	1·2	11·0	12·2
4 . .	6·3	..	6·3	16 . .	..	7·3	7·3
5 . .	12·1	..	12·1	17 . .	6·0	..	6·0
6 . .	27·9	..	27·9	18 . .	12·2	..	12·2
7 . .	21·2	..	21·2	19 . .	15·9	..	15·9
8 . .	10·6	4·5	15·1	20 . .	..	9·3	9·3
9 . .	..	8·4	8·4	21 . .	17·7	..	17·7
10 .	1·3	10·8	12·1	22 . .	14·5	..	14·5
11. . .	8·2	1·0	9·2	23 . .	13·4	..	13·4
12 .	5·9	3·7	9·6	24 . .	9·2	..	9·2
				Country .	..	5·9	5·9

Varietal test. With a view to testing the resisting power of certain Pusa barley varieties to *H. Sativum* four types of barley, *viz.*, T. 7, T. 12, T. 17 and T. 21, were taken and seeds were treated before sowing—(1) seeds sown dry without any treatment, (2) seeds soaked in water for ten minutes, (3) seeds infected heavily with spore suspension in water, (4) heavily infected seeds were disinfected with a 0·1 per cent. solution of mercuric chloride for ten minutes and washed in several changes of water before sowing. All the four types of barley were sown in 96 plots, each treatment for each variety was repeated six times and each plot had 60 plants. All seedlings which died due to foot-rot or root-rot were removed weekly and examined and when the crop was fully grown, the percentage of leaf area destroyed was estimated. No trace of *H. teres* was noted in any of the 96 plots.

The following was the average percentage of deaths due to *H. Sativum* causing foot-rot and root-rot :—

Type	Sown dry (control)	Seeds soaked in water	Seeds infected	Infected seeds disinfected
T.21	20·0	19·1	19·7	15·0
T.17	43·8	48·0	49·1	24·8
T.12	16·1	14·7	20·6	17·3
T.7	18·0	16·4	19·2	16·1

The following was the percentage of leaf area destroyed by *H. Sativum*:—

Type	Seeds sown dry	Seeds soaked in water	Seeds infected	Infected seed disinfected
T.21	1·4	1·7	1·3	1·3
T.17	1·3	1·4	1·2	1·1
T.12	9·9	6·6	9·2	8·1
T.7	6·6	5·4	6·5	5·1

These preliminary results indicate that, except possibly with T. 17, no increase in infection over the control is obtained by deliberate infection of the seeds with spores prior to sowing. This is presumably due to the soil or the seeds already being heavily infected. Infection followed by disinfection reduces the percentage of deaths from foot- and root-rot to well below those of the control in the case of T. 17 and to a lesser extent with T. 21, while varieties T. 12 and T. 7 are unaffected.

Comparison of the figures for percentage of deaths due to root- and foot-rot with those for the percentage of destruction of leaf area in the surviving plants gives a striking result. The more susceptible the variety to foot- and root-rot, the less is the percentage of destruction of leaf area in the surviving plants.

It is intended to test a larger number of barley types and to see the effect of other fungicides for surface disinfection of seeds.

(6) Eleusine coracana.

A study of the diseases of *Eleusine coracana* and *E. aegyptiaca* caused by *Helminthosporium nodulosum* and *H. leucostylum* was completed. Both the species cause leaf-spot, seedling blight and head blight, and *H. nodulosum* is also responsible for foot-rot and root-rot. The fungus is found present on seed and responsible for the non-germination of infected seeds. The optimum temperature for infection was found to be between 30-32° C. though the range of temperature at which infection can take place was from 10-37° C. *H. nodulosum* was found by experiment to have a wide host range and infected wheat, oats, barley, maize, sorghum, sugarcane, *Pennisetum typhoideum, Panicum frumentaceum* and *P. miliaceum.*

The morphology of the parasite both in nature and under various environmental conditions was studied.

(7) Cinchona.

Much work was done on the *Phytophthora* from cinchona. Though it has not formed oospores in pure culture they are produced in mixed

culture with *Ph. colocasiæ*, *P. parasitica*, *F. Faberi*, and *P. palmivorum*. The work on the other fungi found on cinchona plants was continued in the laboratory and in the field.

(8) Piper betel.

Considerable amount of cultural work has been done with the *Phytophthoras* from Bengal, Madras and Malaya and the conclusion has been reached that those from Bengal and Madras are a strain of *P. parasitica* (Dastur) Ashby. Oospores have been found in quaker oat agar, corn meal agar and green pea agar and some study has been made of mixed cultures with *P. arecæ*, *P. Meadii*, *P. palmivora*, *P. colocasiæ* and *P. parasitica*. Bordeaux mixture $2\frac{1}{2} : 2\frac{1}{2} : 50$ prevents the disease in areas not exposed to much flooding.

Rhizoctonia Solani is appearing to a greater extent in some areas and efforts are being made to control it by means of a soil disinfectant.

(9) Capsicum annuum.

A wilt of chilli causing considerable damage to the crop was noticed during the year. The wilt appeared during the fruiting stage of the crop and killed the plant before the fruits were ripe. An examination showed the presence of mycelium in the vascular bundles of roots, shoots and petioles. In severe cases the fungus was found on the fruits and even on seeds. Several isolations were made from mycelium inside the tissue of the diseased plants and in all cases a species of *Fusarium* was isolated. On dead plants or in plants severely attacked the fungus forms spores on the outside of the shoots. This species of *Fusarium* is being studied in culture and experiments are being laid out on a field scale to test the parasitic nature of the organism on various varieties of chillies.

(10) Euchlaena luxurians.

A species of *Helminthosporium* was found to do a good deal of damage to the leaves. It formed brown to dark brown elongated spots running somewhat parallel to the veins, two or more spots sometimes uniting to form an irregular discoloured brownish area. The fungus has been isolated and the pure culture is being compared with other species on cereals.

(11) Rot of Violets.

During the early period of the monsoon in 1930 violet plants died in large numbers. The leaves became pale yellow at the margins and curled. The root stock became soft, the cortex peeled off easily and the central stele was black and soft. Mycelium and sclerotia of *Rhizoctonia batatícola* (Taub.) Butl. were found in abundance within the rotting tissues.

IV. SYSTEMATIC WORK.

Sclerospora Sacchari Miyake on sugarcane leaves, *Colletotrichum cajani* Rengel on *Cajanus indicus* and *Rhizoctonia batuticola* on viola

were for the first time found in Pusa. A collection of specimens received from Professors of Botany, University of Allahabad and Charmichæl College, Calcutta, was identified. Cultures from Professors of Botany, Agricultural College, Lyallpur, and the University of Punjab, Lahore, were identified. Fresh specimens of three rusts on wheat were sent on several occasions to the Professor of Botany, Agra College, for his research on rusts. A number of *Cercosporas* were identified in collaboration with Herr Sydow of Berlin. A species of *Phytophthora* was isolated from *Hibiscus Sabdariffa* from Dacca, a new species of *Sclerotium* on gram at Pusa and *Heterodera radicicola* and a new species of *Alternaria* on tobacco from Rangpur. Three hundred and twenty-three foreign specimens were received from E. B. Copeland of the University of California, Berkley, U. S. A., and fifty-two received from Allahabad and Calcutta, added to the herbarium.

V. PROGRAMME OF WORK FOR 1931-32.

1. Research work.

New diseases of Indian crops that come to the notice of the Section will be investigated. Diseases on the following crops will receive special attention :—Cereals, sugarcane, *rahar*, piper-betel, cinchona, gram and chilli.

The investigations in progress include :—

(i) Isolation of a type of *rahar* resistant to wilt disease caused by *Fusarium vasinfectum* Atk.

(ii) Experiments to determine resistance of Co. varieties of sugarcane to mosaic and tonnage experiments to determine the loss due to mosaic.

(iii) The studies on *Sclerospora* causing downy mildew and fungus responsible for the top-rot disease of sugarcane. the

(iv) Experiments to find out suitable remedial measures to check the diseases of piper-betel.

(v) A study of diseases on cereals and sugarcane caused by species of *Helminthosporium*, *Tilletia indica* on wheat and a new species of *Cercospora* on *rahar*.

(vi) Determination of percentage of " rusts " and *Helminthosporium* on various varieties of wheat and barley.

(vii) Morphology and parasitism of the fungus causing wilt of chilli and resistant trial experiments.

(viii) Morphology and parasitism of *Fusarium* sp. causing wilt, *Mystrosporium* sp. causing leaf blight of gram and remedial measures for the latter.

2. Training.

Students and assistants will receive training on the lines indicated in the prospectus.

3. Routine work.

Advice and assistance as required will be given to other departments and the general public.

VI. PUBLICATIONS.

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Mitra, M. . . . A Comparative Study of Species and Strains of *Helminthosporium* on certain Indian cultivated Crops. *Trans. Br. Myc. Soc.*, Vol. XV, Parts III and IV, pp. 254-93, 1931.

Mitra, M. . . . Saltation in the Genus *Helminthosporium. Trans. Br. Myc. Soc.*, Vol. XVI, Parts II and III, pp. 115-127, 1931.

Mitra, M. . . A new Bunt on Wheat in India. *The Annals of Applied Biology*, Vol. XVIII, No. 2, pp. 178-79, 1931.

Subramaniam, L. S. . A Note on the Downy Mildew of Sugarcane in India. *Agric. and Live-stock in India*, Vol. I, Part 1, pp. 32-33, 1931.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.)

I. CHARGE.

Mr. P. V. Isaac held charge of the Section until 27th October 1930, when I returned from leave.

II. TRAINING.

Mr. Biseshwar Dayal Gupta, M.Sc., Post-graduate student, was under training during the year.

III. INSECT PESTS.

Sugarcane.

Aphis sacchari was very abundant on cane during September and October but in November the numbers present dropped, together with the rate of parasitization. In February the number increased again, winged viviparous females being especially abundant in April even when the maximum temperature was over 100° F. *Parasus* sp. and *Scymnus nubilus*, although present, did not reduce the numbers of this Aphid to any extent. The seasonal variation in parasitization varied considerably, being at its maximum at the end of October.

A Mealy-bug, *Pseudococcus sacchari*, Cockerell, occurred in large numbers, mostly on ratoon canes, but also in a small plot planted in October 1930. In May and June the females were heavily parasitized. When present in large numbers, this mealy-bug reduces the vitality of the plant considerably but its presence easily escapes casual examination owing to its habit of living under the sheathing leaves.

Pyrilla pusana, Distant, *P. aberrans*, Kirby, and *P. perpusilla*, Walker, were all present on the canes. In these insects also parasitization reaches its maximum by the end of October but, with the onset of the cold weather, the rate drops so that a few eggs in each cluster, especially on ratoon canes, eacape parasitization in December and these eggs produce nymphs which find their way onto oats and other succulent grasses during February and the early part of March when no cane is available, and these nymphs become mature by the end of March, by which time the new cane is sprouting. A small experimental plot (0·04 acre) was planted with cane in October 1930 to test the efficacy of the collection of egg-masses, breeding and liberation of parasites in these egg-masses, and bagging of adults. From the middle of March to the end of June 1931, 1821 egg-clusters were collected in this small plot. A Coniopterygid was found to be a predator on the egg-masses.

The Aleyrodid, *Neomaskellia bergii*, was especially abundant during November and January, some plants, on which it occurred together with *Aphis sacchari*, being blackened by this insect.

Two uniform plots were planted with Co. 213 cane to test the effect of planting setts which had been (*a*) examined for Borers or (*b*) immersed in water at normal temperature for 72 hours. From regular countings of the two plots it appeared that, though the setts which had been immersed in water showed a slight improvement over those examined for Borers, the difference was too small to be commensurate with the trouble and expense of carrying out this procedure in the case of extensive plantings.

To determine the incidence of attack of Borers and Termites, a lot of 1,000 canes each was examined on 12th December 1930 of two varieties, Co. 213 and Co. 205, which had been planted on 12th February 1930. The percentages of damage were :—

	Undamaged	*Scirpophaga nivella*	Stem Borers	Root Borer	Termites
Co. 213 . . .	7·1	73·2	23·5	27·7	66·9
Co. 205 . . .	14·1	80·3	8·3	39·0	33·0

(Note.—Many canes were damaged by more than one insect.)

It will be noted that the percentage of canes, which were not damaged by any of these insects, is very low.

Canes of the following Co. varieties, *viz.*, 205, 210, 213, 214, 223, 281, 285, 287, 290, 295, 297, 298, 299, 301, 302, 303 and 305, planted in February 1930, were examined for Borers and Termites before their despatch to the crushing mill. Of these the Top-shoot Borer, *Scirpophaga nivella*, was found to be bad in the following, *viz.*—

	Per cent.
Co. 205	83·3
Co. 210	85·0
Co. 214	83·4
Co. 301	95·0
Co. 303	81·6

whilst Co. 223, with 50 per cent. infestation, was least affected. As regards the Stem-Borers (*Diatræa venosata*, *Argyria sticticraspis* and *Chilo zonellus*) Co. 213 suffered the most (15·5 per cent.) and Co. 231 the least. Termites had attacked Co. 214 the most (16·8 per cent.) and Co. 299 the least (7·7 per cent). In the case of Termites, local conditions (soil, availability of other food, etc.) come into play and too much reliance should not be placed on insufficient *data*.

To determine the total loss brought about by the Top-shoot Borer (*Scirpophaga nivella*), Stem-Borers (*Diatræa venosata*, *Argyria sticticraspis*, and *Chilo zonellus*), and Termites, a small plot (0·04) was planted on 20th October 1930 with 2704 eye-buds of Co. 213 cane. By 20th

June 1931 these had produced 5,817 canes, of which 2,451 (42·13 per cent.) were destroyed by these insects.

To test the comparative merits of deep (6-inch) and shallow (3-inch) planting of setts, experimental sowings were made on 12th February 1931 of Co. 213, 214, 281, 205 and 303. These were examined on 12th June 1931 :—

Variety	Depth	No. of canes in line	No. affected	Percentage affected
Co. 303	Shallow . .	1,445	333	23·04
Co. 303	Deep . .	2,352	457	19·42
Co. 205	Shallow . .	997	122	12·21
Co. 205	Deep . .	865	83	9·59

It would appear, therefore, that deeper planting has some effect against Borers—perhaps because the shallower plantings sprouted up earlier and attracted a larger proportion of the earlier egg-laying.

As the Top-shoot Borer (*Scirpophaga nivella*) is a serious pest of cane and its white moths and buff-coloured egg-masses are fairly conspicuous on the plants, an experiment in control by regular hand-collection of these has been started, and a total of 7,650 egg-masses was collected from 1st March to 30th June 1931. Of these, 193 egg-masses were collected from two small plots with an area of 1·56 acres. It was found that the eggs were actively parasitized during March and April, when 1640 Chalcididoid Parasites were bred and liberated in the fields, but thereafter, owing to abnormally high temperatures, it proved very difficult to breed the parasites. The average cost of collection of egg-masses worked out at 4½ annas per acre per month, this cost being unduly high because the labour was untrained and frequently changed. But the effect of continuous collection of the egg-masses has given tangible results in that the plots so treated contain fewer Borers than in those in which no action has been taken. The systematic collection of the moths and egg-masses in the cane fields certainly seems to give practical results, if properly carried out, preventing damage and being within the capacity of the cane-grower in all areas where labour is available.

The Root Borer (*Emmalocera depressella*) was very active from the beginning of May to the middle of June, being the principal Borer at this time when the other Borers are rendered rather quiescent by the high temperatures prevalent. By the third week in June, it was found to be parasitized by a Braconid.

Other Pests.

Laphygma exigua did some damage to lucerne in April and May. The first moths were noted at light on 14th March and eggs were found

on lucerne a week later and were hand-picked, 1,320 egg-masses being found in an area of 1·5 acres. This moth is a well-known migrant and it is probable that the first moths noted were immigrants.

The larvæ of *Prodenia litura* and *Diacrisia obliqua* damaged mangold wurzel and were treated by timely spraying. The larvæ of *P. litura* also attacked early-transplanted cauliflower seedlings. The first female of *Pieris brassicæ* was noticed on 17th February 1931, rather later than the normal date; this is another migrant which apparently hatches out in the Hills in the early Spring and migrates to the Plains.

Guava trees at Bungaon, Bhagalpur District, were damaged by a Longicorn (*Nothopus hemipterus*, Olivier) whose larvæ were boring in them. The affected trees were treated successfully by injection of Carbon Bisulphide. This is a new pest.

Indarbela sp. damaged *Zizyphus jujuba*, guava, litchi, *Phyllanthus emblica*, *Cassia fistula* and *Bauhinia purpurea*, the larvæ boring in the stems and feeding on the bark. Adults emerged from *Zizyphus* during May and young larvæ occurred in numbers by the end of the month. *Eupterote undata* was especially abundant on *Tecoma grandiflora*, *Pulvinaria psidii* on guava, and *Pseudococcus corymbatus* on bunches of grapes.

The Apricot Eurytomid was reported as occurring in the Attock District, Punjab. This insect was hitherto known only from the North-West Frontier Province. It is referred to in the Annual Report for 1928-29 (p. 71, Plate 3, figure 1) and has now been identified definitely as *Eurytoma samsonovi*, Vass.

An outbreak of *Amsacta albistriga* caterpillars on standing crops occurred at Sirsah, in the Bettiah District, and an Assistant was sent there to investigate.

"Dhupa" (*Vateria indica*) Nuts, received from Mangalore, were found to be badly infested by grubs of a weevil which appeared to be an undescribed species of *Calandra* and has been sent to a specialist in this group for description.

Specimens of *Lophosternus hugeli* were received for identification from Kumaon, where the grub of this Longicorn Beetle is a serious pest as a borer in apple trees, of which about 2½ per cent. are reported to be killed annually by this insect.

Mosquito control work on the Pusa Estate was continued throughout the year, breeding-places near the residential area being treated as required. *Anopheles pallidus* and *A. hyrcanus*, both new to Pusa, were found in cattle-sheds in January 1931. An undescribed species of *Aedes* (*Stegomyia*) was also found amongst tree-hole material at Pusa.

The occurrence of extensive myiasis in sores and wounds of cattle in Wellington (Nilgiris) during the summer months was found to be due to *Chrysomyia bezziana*, Vill., whose eggs are laid close to the seat of injury. A spray of Crude-oil Emulsion at regular intervals was tried as a control measure.

The usual Insectary work of investigating life-histories of insects was carried on as usual, some 130 species of insects having been reared and their stages described and figured. These included numerous novelties which will be described in due course.

Stomoxys calcitrans was bred in December from larvæ found in elephant's dung near Pusa.

IV. BEES AND LAC.

Apiculture. Numerous inquiries were received and information and assistance given as far as possible. There is a considerable demand in India for hives, foundation-comb, and similar apparatus. Hives, prepared by a local carpenter to our standard pattern, and foundation-comb, made in our mill for *Apis indica* comb, were supplied to various correspondents.

Lac. Emergence of Lac larvæ at Pusa took place on 13th October 1930 and 29th June 1931. The Pusa brood-lac of the previous year and the *Palas* (*Butea frondosa*) brood-lac received from Palamau in July 1930 deteriorated during the year. The *Ber* (*Zizyphus jujuba*) brood-lac brought from Dhulian, Ganges, in July 1930 did well in the following October and about 70 small trees were inoculated, but the abnormal heat of May and June 1931, when the shade temperature was over 100° F. for a long period and rose to 113°F., killed off practically all the lac-insects.

V. INSECT SURVEY.

Collections were sent for identification to the following specialists whose help is gratefully acknowledged :—

1. Microlepidoptera to Mr. E. Meyrick, F.R.S.,
2. Asilidæ to Mr. J. R. Malloch, Washington.
3. Pupiparous Diptera to Professor G. F. Ferris.
4. Culicidæ to Captain P. J. Barraud.
5. Copridæ to Mr. G. J. Arrow.
6. Hymenoptera to the Imperial Institute of Entomology.

Specimens received from various correspondents were examined and named as far as possible.

VI. PROGRAMME OF WORK FOR 1931-32.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop pests and especially of the pests of sugarcane, of fruit-trees and stored grains.

Minor.

Results in various lines of work require to be written up and published as far as possible. New insecticides and control methods will be tested as occasion arises. Systematic work will be carried on with our resources and the help of specialist correspondents. The Catalogue of Indian Insects will be proceeded with. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

REPORT OF THE IMPERIAL AGRICULTURIST.

(Arjan Singh Maan, L. Ag., in charge.)

I. CHARGE.

Mr. Wynne Sayer, B.A., officiated as Imperial Agriculturist up to the 17th March, 1931, when he proceeded on leave and I was placed in charge.

II. TRAINING.

Five post-graduate students of animal husbandry and dairying attended a course of training for three months, and studied the general management of a big farm run on modern lines.

One post-graduate student from the Punjab completed his training in sugarcane culture on 2nd November, 1930, and one Probationary Assistant Director, Bihar and Orissa Department of Agriculture, finished his course in general agriculture on 16th April, 1931.

Two post-graduate scholars, one sent by the Jaipur Durbar and one from the United Provinces Agricultural Department, were taken in for training in general agriculture.

III. ADVICE AND SEED SUPPLY.

The officiating Imperial Agriculturist investigated the development of sugar industry in the North Bihar sugarcane tract and gave advice to the sugarcane-growers. The cultivation of berseem was demonstrated on Viceroy's Body Guard Farm at Dehra Dun. A demonstration and trial of a semi-Diesel crude oil Lanz Bulldog tractor was held at Pusa on 2nd November, 1930, and two following days.

The demand for improved seed of various crops increased considerably : 1,476 maunds oats, 371 maunds wheat, 51 maunds barley, 814 maunds sugarcane setts and 48 maunds maize and other miscellaneous seeds were distributed. Samples of soil scrapers and archimedian screw were also supplied. Advice by correspondence was given on various agricultural matters to a large number of enquirers.

A large number of visitors from all parts of the country visited the Section and were given facilities to see round the farm and dairy.

IV. FARM CULTIVATION AND FIELD EXPERIMENTS.

Season. The total rainfall during the year from June, 1930, to May, 1931, amounted to 33·8 inches as compared with 50·17 inches in the corresponding period of the previous year. The monsoon rainfall, though below average, was well distributed for the successful growth

of maize and other *kharif* crops except paddy. The four inches rain on 19th and 20th June, 1930, penetrated the deep ploughed soil right through and sowings of *kharif* crops were successfully completed without break. The late heavy rain in the month of September interfered with the preparation of soil for *rabi* sowing ; consequently the *rabi* cereals were short in straw and the yield was below normal.

The cold weather rains, though they benefited the oats and wheat crops, were harmful to gram and *arhar* (*Cajanus indicus*), the flowers of which were damaged.

Reserved area. An area of 130 acres was reserved for the field experiments carried out for the other Sections. Four and a half acres of this were utilized for a trial of wheat Pusa 52 *versus* country wheat which was carried out in Jhilli field for the Imperial Agricultural Bacteriologist. The plots were laid out in narrow long strips of $\frac{1}{4}$ acre each and each variety was repeated nine times. There was no significant difference between the two varieties which each yielded about $14\frac{1}{2}$ maunds per acre.

On the remainder of the reserved area the improved types of chillies, oats, wheat, barley, *arhar*, gram, linseed and hibiscus were grown for the Imperial Economic Botanist for yield tests on field scale and for multiplication of pure seed. In order to keep the seed pure and obtain actual yield figures of different types, considerable work had to be done by means of manual labour instead of machinery. The statement of yields obtained has been supplied to the Imperial Economic Botanist who has dealt with the results in his report.

Maize. Single plant selection work was continued on the three selections No. 1 white, No. 2 yellow and No. 3 big white. These three varieties yielded as follows when grown in comparison with *desi* maize in the Punjab field on an area of eight acres divided into $\frac{1}{4}$-acre plots. No manure was applied to the crop.

Serial No.	Maize variety	Average yield of grain per acre	Average yield of green matter per acre
		Md. sr.	Md. sr.
1	No. 1	16 1	169 13
2	No. 2	13 19	164 0
3	No. 3	15 33	145 0
4	Local	12 36	117 27

The table shows that all the three varieties gave higher grain and green material per acre than the local material, No. 1 (white) being the best.

The average grain yield of maize No. 3 on a field manured with 4,099 lb. of farmyard manure was 27 maunds 35 seers, and the highest from one plot was 31½ maunds.

The Assistant Controller of Grass Farms, 3rd Circle, Lahore, experimented at Lahore on maize Nos. 1 and 2 supplied from Pusa in comparison with local maize. The results obtained by him are given below and show that the Pusa maize was much superior :—

Variety	Acreage sown	Total outturn	Outturn per acre
	Acre	lb.	lb.
Pusa maize No. 1 (white)	1	47,970	47,970
Pusa maize No. 2 (yellow)	1	47,438	47,438
Local variety	¾	24,766	33,021

He remarked that the stem development of Pusa maize was finer than in the local variety which accounted for the greater leaf production. By comparison, the crops produced from Pusa seed appeared to be more suitable than the local variety.

Sufficient seed of all the three varieties has been supplied to the same officer this year to make the experiment on a large scale.

Oats. On account of the short rainfall, the oats crop was short in straw and below average in yield. The average outturn per acre from an area of 178·25 acres was 14·4 maunds as compared with 21·44 maunds last year. The old local variety of oats has been replaced by the improved type B. S. 1 which is slightly better in yield and heavy in grain. Although the prices of all other food grains fell considerably the price of oats remained practically unchanged. There was a great demand for oats both for seed and feeding purposes.

Peas. Selection work on peas was continued. The comparative yield tests were not conclusive as the crop was damaged by cold weather rains when it was in flowering stage. Three pure selections have been isolated. They are very heavy yielders and grow better on heavy soil than on light soil.

Berseem. Cultivation of berseem as a cold weather green fodder crop was continued in the *dhab* (low-lying) area of 130 acres followed by maize and *meth* (*Phaseolus aconitifolius*) mixed in the hot weather by means of irrigation. This area was brought under cultivation some eleven years ago and the above crops have been continuously grown without any manuring. The only manure the land received during this long period was the droppings of the cattle at the time of grazing berseem on the field. The exhaustive effects of this intensive cropping are now visible, as the yields of both berseem and maize have gradually

decreased. The yields for the year under report compare as follows with those in the year 1923-24.

	Green berseem per acre	Maize green per acre
	Mds.	Mds.
1923-24	468	300
1930-31	228	159

To ascertain the effect on the fertility of the land, one maize crop has been eliminated and the rotation now followed each year is berseem-maize in alternate *dhabs*.

Green-manuring. The green pulses, some of which make excellent fodder crops, were tried for their green manure value in A block, Punjab field. One series of 4 one-quarter-acre plots was allotted for each. Pusa 52 wheat was grown in the *rabi* season. The yields were as given below :—

Plot No.	Green manure	Average outturn of wheat Pusa 52 per acre
		Md. sr. ch.
1	Florida velvet-bean	10 38 8
2	*Meth* (*Phaseolus aconitifolius*)	12 12 0
3	*Guar* (*Cyamopsis psoralioides*)	11 1 0
4	*Val* (*Dolichos lab-lab*)	14 10 0
5	Cowpeas (*Vigna catjang*)	13 22 0
6	Sann-hemp (*Crotalaria juncea*)	14 7 0
7	Soybean (*Glycine hispida*)	12 27 0
8	Fallow	13 31 0

The results are inconclusive. This is not surprising, and accords with other experiences on the erratic results of green manure trials.

General fertility experiment. The effect of the permanent rotation on the fertility of land, which has been carried out on an area of 413 acres for the last eighteen years, has been shown in the statement given in last year's report. An area of 124 acres has been cut out of those 413 acres in order to carry out field experiments for the other Sections of the Institute. The rotation is, therefore, now being continued on the remaining fields.

Rahar wilt experiment. This experiment was carried out in Punjab field, D block, in collaboration with the Imperial Mycologist. *Rahar*

A.4, a wilt-resistant type, was grown against T. 1, a type highly susceptible to wilt. The two types were interstripped in alternate rows in six plots of $\frac{1}{4}$ acre each. The actual yields obtained are given below and amply confirm the advantage of the wilt-resistant type.

Rahar type	Plot No.					
	10-D	11-D	25-D	26-D	27-D	28-D
	Md. sr.	Md. sr.	Md. sr.	Md. sr.	Md. sr.	Md. sr.
A. 4	2 35	2 0	3 0	2 19	2 14	1 39
T. 1	0 3	0 10	0 38	1 6	0 16	0 24

Trial of ammophos against calcium cyanamide. Ammophos was applied in a half-acre plot at two maunds (cost of 2 maunds=Rs. 16-8) per acre in comparison with calcium cyanamide at the rate of three maunds per acre, the value of the latter manure also being the same. Both were applied before sowing maize in *kharif ;* after harvesting maize oats were grown in *rabi*. The results were :—

Plot No.	Treatment.	Outturn of maize grain per acre	Outturn of oats grain per acre
		Md. sr.	Md. sr.
2	Ammophos worth Rs. 16-8 per acre, *i.e.*, at 2 maunds per acre applied before *kharif* sowing.	11 16	7 30
3	Control (no manure)	10 26	11 20
4	Calcium cyanamide worth Rs. 16-8 per acre, *i.e.*, 3 maunds per acre applied before *kharif* sowing.	11 26	14 14
5	Control (no manure)	7 12	11 34

On a cash basis, calcium cyanamide was to be preferred, especially for the following *rabi* crop.

Bullock plough experiment. This experiment has been laid out in the North Pangarbi field, the soil of which is a medium light type, to obtain definite data on the working, suitability and general upkeep, costs,etc., of some light ploughs designed as improvements on the country plough. Six of such ploughs, namely, (1) local plough, (2) Pusa-made bar plough, (3) Hindustan plough, (4) Shanti plough, (5) Behar plough and (6) Victory plough have, each, been allotted a plot of half acre to be separately cultivated. The cropping scheme followed is :—(1) Maize and peas, (2) maize and barley, (3) maize and *arhar*, (4) maize and wheat. The plots received farmyard manure at 4,000 lb. per acre and ammophos at 100 lb. per acre in alternate years. The results are carefully recorded and are expected to give interesting information in due course.

Permanent manurial experiments. These experiments have been altered according to the recommendations of the Board of Agriculture,

1929. Four new plots have been added—two to each series—making eighteen plots in one series. These have been divided into three groups as follows :—

Group I consists of the plots Nos. 1 to 5 to test the effect of organic manures on the fertility of the plots as follows :—

Plot No.	Treatment
1	No manure (Check plot No. 1).
2	4,000 lb. farmyard manure per acre.
3	8,000 lb. farmyard manure per acre.
4	4,000 lb. farmyard manure *plus* rape cake at the rate of 20 lb. N per acre.
5	Rape cake at the rate of 40 lb. N per acre.

The farmyard manure is applied in accordance with local practice, *i.e.*, in the hot weather and the cake applied to plot 4 is given at the time of the last inter-cultivation. For plot No. 5 one-half of the cake is applied at the time the *kharif* crop is sown and the remainder when the cake is given to plot No. 4.

Group II consists of plots Nos. 6, 7, 8, 9, 10, 11, 13 and 14 to deal with the application of ingredients of chemical manures singly and in combination as detailed below, the artificial manures to be applied in two doses, half before *kharif* sowing and half before *rabi* crop sowing, except during the year when *arhar* is grown.

Plot No.	Treatment
6	Ammonium sulphate : N=40 lb. per acre.
7	Potassium sulphate : K_2O_5=50 lb. per acre.
8	Superphosphate : P_2O_5=80 lb. per acre.
9	Potassium sulphate and superphosphate at above rates.
10	Potassium sulphate, superphosphate and ammonium sulphate at above rates.
11	Ammonium sulphate and superphosphate at above rates.
13	No manure (Check plot No. 2)
14	Ammonium sulphate and potassium sulphate.

Group III consists of plots Nos. 12, 15, 16, 17 and 18 as per details below to determine how far the soil fertility is affected by growing leguminous crops in a rotation and how far they can replace manures.

Plot No.	Treatment
12	Green manure in conjunction with a purely cereal rotation.
15	Effect of green manure and a leguminous crop in the rotation.
16	As for No. 15 but with the additional application of superphosphate (P_2O_5=80 lb. per acre).
17	No leguminous crop and no green manure.
18	The proposed new cropping scheme without any manurial applications (Check plot No. 3).

The Board recommended the following four-year eight-course cropping scheme in place of three-year six-course rotation :—

1	Maize	Barley
2	Maize	*Arhar* (*Cajanus indicus*)
3	Maize	Wheat
4	Maize	Peas

The results obtained during the year under report are given in the statement given below :—

Plot No.	Treatment	A SERIES			B SERIES		
		KHARIF 1930	RABI 1930-31		KHARIF 1930	RABI 1930-31	
		Maize	Peas	Barley	Maize	Barley	Wheat
	GROUP I.	lb.	lb.	lb.	lb.	lb.	lb.
1	No manure (Check plot No. 1) . .	731	460	..	755	402	..
2	Farmyard manure @ 4,000 lb. per acre.	1,355	591	..	1,421	599	..
3	Farmyard manure @ 8,000 lb. per acre.	1,807	764	..	1,905	829	..
4	Farmyard manure @ 4,000 lb. per acre, rape cake @ 20 lb. N per acre to be applied at last inter-culture.	2,004	665	..	2,193	985	..
5	Rape cake @ 40 lb. N per acre—half before *kharif* sowing and half at the time of last inter-cultivation.	1,462	394	..	1,642	714	..
	GROUP II.						
6	Sulphate of ammonia @ 40 lb. N per acre. Half before *kharif* sowing and half before *rabi* sowing.	402	238	..	419	493	..
7	Sulphate of potash @ 50 lb. K_2O per acre. Half before *kharif* sowing and half before *rabi* sowing.	328	304	..	345	370	..
8	Superphosphate @ 80 lb. P_2O_5 per acre. Half before *kharif* sowing and half before *rabi* sowing.	1,297	624	..	1,133	739	..
9	Sulphate of potash @ 50 lb. K_2O. Superphosphate @ 80 lb. P_2O_5 per acre. Half before *kharif* sowing and half before *rabi* sowing.	1,150	337	..	1,076	780	..
10	Sulphate of potash @ 50 lb. K_2O per acre. Sulphate of ammonia @ 40 lb. N per acre. Superphosphate @ 80 lb. P_2O_5 per acre. Half before *kharif* sowing and half before *rabi* sowing.	1,692	534	..	1,552	1,043	..
11	Sulphate of ammonia @ 40 lb. N per acre. Superphosphate @ 80 lb. P_2O_5 per acre. Half before *kharif* sowing and half before *rabi* sowing.	493	608	..	542	345	..
13	No manure (Check plot No. 2) . .	230	328	..	263	394	..
14	Sulphate of ammonia @ 40 lb. N per acre. Sulphate of potash @50 lb. K_2O per acre. Half before *kharif* sowing and half before *rabi* sowing.	337	16	..	682	558	..

Plot No.	Treatment	A SERIES			B SERIES		
		KHARIF 1930	RABI 1930-31		KHARIF 1930	RABI 1930-31	
		Maize	Peas	Barley	Maize	Barley	Wheat
		lb.	lb.	lb.	lb.	lb.	lb.
	GROUP III.						
12	Green manure in conjunction with a purely cereal rotation.	G. M.	..	575	G. M.	..	450
15	Effect of green manure and a leguminous crop in rotation.	797	435	..	G. M.	1,207	..
16	As for plot No. 15 but with an additional application of superphosphate @ 80 lb. P_2O_5 with green manure per acre.	1,092	714	..	G. M.	2,521	..
17	No leguminous crop and no green manure.	854	..	370	616	..	246
18	No manure (Check plot No. 3) . .	755	468	..	386	542	..

SUGARCANE.

The main experimental work on sugarcane crop was continued in the New Area which is now fully designed for the purpose. All the four blocks have been levelled and put under a four-year rotation as the light soil of the area is unable to stand a three-year rotation. The rotation followed is :—

	1st year	2nd year	3rd year	4th year
Kharif . . .	Sugarcane .	Green pulse .	Maize . .	Green pulse
Rabi . . .	Sugarcane .	Oats . .	Berseem .	Fallow

The blocks 1, 2 and 3 have had berseem, the effect of which on the succeeding crop of sugarcane was marked.

Sugarcane was grown in block No. 2 during the year under report. Testing of new varieties on field scale was carried on in Bhograsan field on the old farm. The following are the lines of work :—

1. Tonnage experiments.
2. Manurial experiments.
3. Variety tests (field scale).
4. Nursery work (multiplication of new varieties).
5. Mosaic experiments in collaboration with the Imperial Mycologist.
6. Cost of growing cane.

Tonnage experiments. (*a*) To collect definite data as to which of the standard Co. varieties 210 and 213 is the best for the light soils of the White Sugar Tract, an experiment was laid down at the New Area on a

Sugarcane varieties Co. 285 and Co. 205 planted in February and photographed before the break of monsoon, showing the advanced growth of Co. 285.

plot of ten acres. The two varieties were grown interstripped in rows of four 600 feet in length and were duplicated. There were thus thirty-six replications of each variety. To avoid the side effect only two middle rows were weighed. The average yield of Co. 210 was 483 maunds per acre against 420 maunds of Co. 213. On four strips out of thirty-six Co. 213 was better than Co. 210. The experiment is being continued.

(*b*) In order to select a suitable cane in place of Co. 205 which is not favoured by the mills, Co. 285, Co. 295 and Co. 205 were interstripped as above on low land and each repeated four times. The yield of Co. 285 was 604 maunds stripped cane against 446 of Co. 205, while Co. 295 gave 368 maunds only. The higher sucrose content of Co. 285 (15 per cent. in November against 12·66 per cent. in Co. 205), combined with high tonnage, drought-resisting capacity, rapid growing quality and other desirable agricultural habits, confirm its superiority over Co. 205. The accompanying photograph (Plate I) of February-planted crops of Co. 205 and Co. 285 shows a distinct difference in the growth before the break of monsoon in favour of Co. 285.

(*c*) As regards Co. 223 and Co. 210 which are two similar canes, one being a standard variety in the Punjab and the other in North Bihar, a final test was carried out in the New Area. Co. 223 was interstripped with Co. 210 in rows of four and there were eight replications of Co. 210 and seven of Co. 223.

The results are given below :—

	Average yield per acre Md.
Co. 210	454
Co. 223	339

Manurial experiments. (*a*) In collaboration with the Imperial Agricultural Bacteriologist, a manurial experiment was laid down in New Area on Co. 210. The general scheme and outturn in maunds and seers per plot is given below :—

S.

	A	C	D	B	A	C	D	B
	50-20	52-5	56-25	62-5	61-0	58-5	64-25	64-30
E.								W.
	B	D	C	A	B	D	C	A
	71-20	72-20	68-30	68-20	70-25	69-15	76-10	68-30

N.

A=10 maunds oil-cake and 2 maunds nitrate of soda per acre.
C=15 maunds oil-cake and 2 maunds nitrate of soda per acre.
D=20 maunds oil-cake per acre.
B=15 maunds oil-cake per acre.
Area of each plot—$\frac{1}{8}$th of an acre.

The results show that 15-20 maunds of oil-cake gave the highest returns, and that nitrate of soda in addition to, or in part replacement of, oil-cake had no advantage.

(*b*) The outstanding results of the experiments with sulphate of ammonia and nitrate of soda applied as top-dressing, in addition to standard manuring, to Co. 210 and Co. 213 are as follows :—

1. The average yield of Co. 210 in sulphate of ammonia plots is 518 maunds per acre against 447 maunds with nitrate of soda, an increase of 16 per cent.
2. The average yield of Co. 213 with sulphate of ammonia is 441 maunds per acre as compared with 399 maunds with nitrate of soda, an increase of a little over 13 per cent.
3. Sulphate of ammonia applied at two maunds per acre as top-dressing in two doses (middle of June and middle of July), in addition to standard manuring, gave the best results.

Variety tests. The following varieties were grown in the Bhograsan field on an estate-scale against standard canes.

Varieties	Area	Yield per acre in maunds
Co. 210	1·47	403·21
Co. 213	0·198	*749·50*
Co. 214	0·168	275·71
Co. 223	0·250	399·28
Co. 270	0·900	399·85
Co. 296	0·042	153·57
Co. 298	0·560	290·98
Co. 299	0·630	*491·62*
Co. 300	0·170	320·58
Co. 301	0·500	374·64
Co. 302	0·750	372·87
Co. 303	0·570	*685·65*
Co. 310	0·100	407·50
Co. 312	0·350	*572·14*
Co. 313	0·310	*495·16*
B. S. 4	0·250	264·28
B. S. 11	0·960	*635·90*
B. S. 14	0·042	226·19
B. S. 15	0·230	227·04
Co. 243	0·070	234·28

The new varieties which were planted in New Area on field-scale are as follows :—

Varieties	Area	Yield per acre in maunds
Co. 281	0·64	442·5
Co. 285	0·214	604
Co. 210	0·53	454·7
Co. 223	0·47	339·3
Co. 295	0·228	367·5
Co. 205	0·228	446·2
Co. 290	0·23	171·7
Co. 298	0·15	126·6
Co. 299	0·44	271
Co. 300	0·08	540·6
Co. 301	0·08	662·5
Co. 302	0·23	287
Co. 303	0·88	475
Co. 304	0·04	812·5
Co. 305	0·16	217·0
Co. 307	0·16	243·8
Co. 308	0·28	292
Co. 315	0·44	216
Co. 316	0·37	383·8

The analysis month by month of some high tonnage canes is given below as compared with standard varieties :—

Varieties.	Sucrose per cent in juice.			
	November	December	January	February
Co. 210	14·67	15·97	14·97	..
Co. 213	14·20	14·89	15·36	..
Co. 214	16·31	16·48	17·78	..
Co. 299	16·95	17·64	16·13	17·38
Co. 303	13·06	16·14	15·81	17·85
Co. 312	11·26	15·86	..	..
Co. 313	13·64	13·61	15·97	18·21
B. S. 11	13·09	15·86	15·41	..
Co. 281	16·66	18·12	17·69	17·49
Co. 285	15·11	16·54	16·99	16·88
Co. 304	13·14	16·03	14·86	17·29

Co. 299 is an early cane with combination of high sucrose and fair tonnage, grows well and has a habit of standing upright. It has been planted on an area of two acres interstripped with Co. 214 as it compares well with this standard variety.

Co. 303 compares well with Co. 210 and Co. 213 and is a medium thick cane. It has got a drought-resistant capacity. It is a cane to grow on salt land. It tillers well and is a heavy yielder. The only defect is its lodging habit.

Co. 312 is a quick germinator, stands up erect, tillers well and resists drought. Cane formation begins early.

Co. 313 is a medium cane with dark green leaves, grows well before rains and is a strong tillerer. It makes a good stand after the rains and is suitable for growing on heavy lands.

Co. 281, with which we are struggling to make it grow successfully, is a very early cane with high sucrose percentage. It is an excellent cane provided we can grow it. It suffers from white ants and root-borers. Some of the stools were very healthy and showed a promise of success.

Co. 304 is like Co. 312 which grows well in the hot weather, germinates quickly and cane formation starts early. The area under this variety was too small to arrive at a definite conclusion regarding yield.

B. S. 11 is the healthiest of the B. S. lot. It tillers well and fills up the rows thickly and is a short heavy cane.

Nursery work. The new Coimbatore varieties of sugarcane which were multiplied up in the nursery have been planted in the field, and these are Co. 317 to Co. 337. The P. O. J. 2878 is still in the nursery.

Co. 324, Co. 326, Co. 331 and Co. 336 look so far promising. Material will be available for complete analysis next cold weather.

The Sugarcane Expert supplied in March last 15 new canes, *viz.*, Co. 338 to Co. 350, Tuc. 393, Tuc. 472, and seven sorghum hybrids, *viz.*, Co. 351 to Co. 357. All of them have been planted in the nursery and will be multiplied by short planting. The sorghum hybrids are thick canes with broad leaves, except Co. 352 which is a thin variety with narrow leaves. Some of them have started throwing out adventitious roots. Co. 354 and Co. 356 hybrids are promising.

Mosaic and insect pests. Experiments were carried out in collaboration with the Imperial Mycologist and the Imperial Entomologist to deal with the mosaic disease of sugarcane and insect pests. For mosaic tonnage, an experiment was laid out in Gonhri and Co. 213 was grown on paired plots, 7×50 yards each in area. There were ten pairs of each, healthy and mosaic. To eliminate the end and side effect 6 feet at each end and one row on both sides of each plot were left out. A similar experiment was carried out in the New Area with Co. 205.

Sugarcane varieties Co. 213 and Co. 205 were planted in North Pangarbi on a half-acre plot for the study of insect pests. Full details of the results of these experiments will be found in the reports of the above Sections.

As a result of the constant attention paid by the Mycological Section, the main crop on the farm was practically free from mosaic but the borer attack was more than usual.

Cost of growing sugarcane. The cost of cultivation of sugarcane on three fields is as follows :—

At New Area the average cost per acre for growing sugarcane on a block of 28 acres was Rs. 116. This includes Rs. 65 per acre spent on manures. The average yield per acre was 409 maunds. Cost per maund annas 4·53.

In Bhograsan field (ten acres) variety tests, the cost of cultivation amounted to Rs. 98 per acre with an average yield of 445·4 maunds per acre. Cost per maund annas 3·52.

Twenty acres were planted under Co. 205 in Brickfield II low land. It was a non-experiment general field crop grown without manure. Long canes were planted in furrows opened by means of three-row ridge. The average cost per acre was Rs. 49, while the yield amounted to 378·5 maunds. Cost per maund annas 2·27.

The prices of all the agricultural produce fell considerably but the price paid by the sugar mills for the cane remained unchanged. Under the present conditions this is the only crop to which the ryot can turn as a revenue crop, and its cost of production can be considerably reduced owing to oil-cake for manuring being available at cheap rates. The present price of oil-cake is Rs. 1-8 per maund in the market as against Rs. 4 paid last year.

The following varieties have been discarded as being unsuitable for further trials :—

Co. 295, Co. 296, Co. 300, Co. 307, Co. 290, B. S. 4, B. S. 14, B. S. 15, Co. 310, Co. 311 and Co. 223.

V. MACHINERY.

The following power units were at work on the farm during the year under review for cultivation purposes :—

1. Fowler Double Steam Engine Cable Ploughing Set.
2. Vickers Kerosene Oil 23-40 H. P. English Tractor.
3. International Harvestor Companies' McCormick Deering Kerosene Oil 15-30 H. P. Tractor.
4. Lanz Bulldog 15-30 H. P. Crude Oil Tractor.

The details of work, consumption of fuel and lubricants and costs of cultivation operations are given below :—

Output.

Name of set	Ploughing		Disc-harrowing acres per hour	Grubbing acres per hour	Drilling acres per hour
	Depth of ploughing	Acre per hour			
	inches				
1. Steam Tackle . .	10-11	1·03	1·77	2·68	..
2. Vickers Tractor . .	7-8	1·04	1·70	1·65	2·15
3. McCormick Deering .	7-8	0·80	1·69	1·78	2·00
4. Lanz Bulldog Tractor .	5-7	0·77	1·78	2·18	1·59

Output—contd.

Name of set	Ploughs used
1. Steam Tackle	Anti-balance Gang Plough.
2. Vickers Tractor	Vice-Consul five-furrow.
3. McCormick Deering	Little Genius four-furrow.
4. Lanz Bulldog Tractor	Little Genius three-furrow.

Fuel and lubricants consumed per hour.

Name of set	Fuel		Lubricants per hour
	Kind of fuel	Consumption per hour	
1. Steam Tackle	Steam coal	3·65 maunds	0·16 gallon.
2. Vickers Tractor	Kerosene oil	2·84 gallons	0·20 gallon.
	Petrol	0·09 gallon	
3. McCormick Deering	Kerosene oil	2·1 gallons	0·14 gallon.
	Petrol	0·06 gallon	
4. Lanz Bulldog Tractor	Crude oil	1·72 gallons	0·15 gallon.

Cost per acre.

Name of set	Ploughing	Disc-harrowing	Grubbing	Drilling
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
1. Steam Tackle	5 4 3	3 0 9	2 0 1	..
2. Vickers Tractor	4 0 5	2 7 4	2 8 7	1 15 2
3. McCormick Deering.	2 15 0	1 6 2	1 5 1	1 2 8
4. Lanz Bulldog Tractor.	2 2 8	0 14 10	0 12 1	1 0 9

The McCormick Deering tractor, though working for more than four years, required spare parts to the value of Rs. 46 only.

No trouble was experienced with the Vickers tractor regarding spare parts, as most of the standard parts of the McCormick Deering tractor fit this machine. Rs. 486 were spent on spare parts.

A three days' trial and demonstration was held with the crude oil tractor Lanz Bulldog in the month of November 1930. An article on the trial written by Mr. Wynne Sayer, officiating Imperial Agriculturist, has been sent for publication.

The following points may be noted :—

1. The listed H. P. 15-30 does not correspond to the rated H. P. of the McCormick Deering kerosene oil tractor, and thus the Lanz Bulldog is unable to work with the plough used for the McCormick Deering.

2. Piston and piston rings get jammed and require cleaning at least once a week. Piston rings break often.

3. Fusible plug and air chamber require cleaning every morning.

4. Spare parts worth Rs. 115 were required during the first ten months (393 working hours).

The Ransomes Consul Thresher worked satisfactorily. Excellent *bhusa* (chopped straw) was made out of wheat straw.

The small " Peasant Thresher " was purchased in March, 1931, but the wooden frame of the shoe was broken on the very first day it was put to trial. The machine could not, therefore, be given full test. While it cannot be driven with hand labour, the tractor power was found excessive for working this machine. It will therefore be tried with a bullock gear next season.

VI. CATTLE BREEDING.

The year under review started with 294 head of cattle in the herd and ended with 251. The general condition of the cattle was good throughout the year. There were, however, two attacks of foot-and-mouth disease among the young male stock kept at the New Area, and three young male calves died of hyperpyrexia resulting from the complications of the disease. As the outbreak has occurred during the last two years, the young stock was removed temporarily from the New Area. The paddocks were thoroughly ploughed up and exposed to sun and air.

After the discontinuance of cross-breeding, the number of cows was restricted to produce sufficient milk for the requirements of the staff of the Institute. Therefore with the limited number of cows, full attention was devoted to the selective breeding of pure Sahiwals for uniformity of type and high milk yield. The female stock has now been grouped in five distinct families with one selected bull for each.

As a result of the rigid selections since 1914, this breed has shown a steady improvement towards the production of large quantity of milk with high fat percentage, contrary to the general statement that high milk producers yield milk with low fat content. The average fat per cent. of the Sahiwal breed here is 4·7 which is really a valuable factor in a dairy breed.

Out of the 76 Sahiwal cows on the roll at present, excluding 19 heifers calved for the first time, five have given over 6,000 lb. of milk, 14 over 5,000 lb. and 11 over 4,000 lb. in 300 days.

The following are some of the selected Sahiwal cows which completed their lactation during the year :—

Serial No.	Name and No. of cow	Date of birth	Number of calving	Quantity of milk given	
				lb.	(days)
1	Nasoorti 427	8th March 1921	6	6,187	(306)
2	Adami 503	25th May 1924	3	6,114	(303)
3	Bendi 467	6th January 1923	4	5,949	(306)
4	Bina 356	22nd June 1918	6	5,862	(303)
5	Atuly 480	22nd November 1923	3	5,784	(304)
6	Munni 454	2nd September 1922	5	5,574	(304)

Calf-rearing. Weaning calves and feeding them at the pail was continued. The percentage of mortality among the young calves has gradually gone down to five from seventeen in the year 1925-26. Details are given below :—

Year	Births			Deaths			Percentage of mortality
	Montgomery	Cross-bred	Total	Montgomery	Cross-bred	Total	
1929-30	40	68	108	7	1	8	7·4
1930-31	47	33	80	3	1	4	5·0

Percentage of cows in milk. For a commercial dairy concern, the regular and constant supply of milk, throughout the year, is an important factor, and this can only be accomplished if the number of cows in milk is maintained at a constant figure. The table showing the number of cows in milk month by month during the year is given in Appendix I. The average percentage of Montgomery cows in milk was 45·7 against 45 in the previous year.

Milk yield. The average yield per day per cow in the Montgomery herd shows an increase over the last year. The steady increase during the months of January, February, March and April is due to the fact that cows had been on full green berseem ration during this period (Appendix II). As a result of selective breeding combined with high standard of feeding the milk of this breed has gradually increased during the last ten years. (Appendix III.)

Clean milk. Bacterial tests were continued by the Imperial Agricultural Bacteriologist. During the period July 1930 to June 1931 110 samples were tested for bacterial counts and coliform germs. Out of these 110 samples, only four showed an abnormal rise in bacterial counts, while all the rest contained less than 10,300 germs per c.c., the lowest being 500 per c.c.

The simple economical method adopted for the production of high standard clean milk was only the ordinary system of jet steaming for sterilisation of milk cans and pails, the usual precautions of milking the cows clean and the ordinary attention paid to the personal cleanliness of the milkers.

Sale of cattle. No public auctions were held during the year. The cattle were sold at valuation prices and on individual offers. (Appendix IV.)

Articles on the following subjects were sent for publication in the *Indian Journal of Veterinary Science and Animal Husbandry* :—

1. A simple monstrosity in cows.
2. An interesting case of cystic calculi.
3. Investigations into the fluctuations of milk yield with the advancement of lactation.
4. The effect of season of calving on milk yield and calving period of Montgomery cows.

VII. PROGRAMME OF WORK FOR 1931-32.

1. The practical treatment of a pedigree dairy herd of pure Sahiwal cattle for milk production.

2. Practical treatment of a 1,200-acre mixed farm with particular attention to profitable modern machinery and the financial results of the work, and included in the above is the study on a practical scale of :—

(*a*) Rotations.

(*b*) Crops for fodder, seed and silage.

(*c*) Implements and machinery.

(*d*) Technique of cultural operations.

3. Continuation of collection of data and results regarding the cost and capabilities of the steam ploughing tackle on estates of this size.

4. Experiments with various types of motor tractors and ploughs for collection of data and working costs and for determination of most suitable types of tractors and implements for India. Also collaboration with manufacturers regarding the manufacturing and introduction of improvements in standard types to suit Indian conditions.

5. Experiment work at Pusa—

(*a*) Rotational experiments.

(*b*) Trial of new varieties of crops, especially leguminous fodder crops.

(*c*) Manurial experiments, especially seasonal and quantitative tests with phosphates.

(*d*) Trial of sugarcane varieties suitable for growth without irrigation.

(*e*) Crop experiments in collaboration with the sectional officers.

6. Demonstrations, exhibitions and sales of surplus dairy stock, etc., will be held from time to time as occasion offers.

7. Touring and advisory. Visits will be paid to provincial agricultural centres.

8. Training of post-graduate students.

Appendix I.

Statement showing the percentage of cows in milk and dry for the year 1930-31.

Month	NUMBER OF COWS IN MILK AND DRY							
	Cross-bred cows				Montgomery cows			
	Total	In milk	Dry	% in milk	Total	In milk	Dry	% in milk
July, 1930. . .	35	28	7	80·0	65	33	32	50·7
August ,, . . .	33	26	7	78·8	67	34	33	50·7
September ,, . . .	33	25	8	75·8	72	38	34	52·7
October ,, . . .	34	23	11	67·6	73	39	34	53·4
November ,, . . .	36	25	11	69·4	66	32	34	48·5
December ,, . . .	36	26	10	72·2	68	29	39	42·6
January, 1931 . .	35	22	13	62·9	69	31	38	44·9
February, ,, . .	35	22	13	62·9	70	30	40	42·9
March, ,, . .	35	23	12	65·7	70	28	42	40·0
April, ,, . .	34	23	11	67·6	72	27	45	37·5
May, ,, . .	34	25	9	73·5	74	31	43	41·9
June, ,, . .	34	25	9	73·5	76	32	44	42·1
Average . . .	34	24	10	70·8	70	32	38	45·7
Average for 1929-30. .	62	42	21	66·8	62	28	34	45·0

Appendix II.

Statement of Milk Yield for 1930-31.

Month	Milk yield of		Total of cross-bred and Montgomery cows	Average yield per day and per cow per day					
				Cross-bred cows		Montgomery cows		Total of cross-bred and Montgomery cows	
	Cross-bred cows	Montgomery cows		Average per day	Average per cow per day	Average per day	Average per cow per day	Average per day	Average per cow per day
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
July 1930	16,129	14,861	30,990	520	18·6	480	14·5	1,000	16·4
August 1930	14,104	14,618	28,722	455	17·5	471	13·9	926	15·4
September 1930	12,977	14,061	27,038	433	17·3	469	12·3	901	14·3
October 1930	12,133	13,477	25,610	391	17·0	435	11·2	826	13·3
November 1930	12,191	9,574	21,765	406	16·2	319	10·0	726	12·7
December 1930	17,381	10,232	27,613	561	21·6	330	11·4	891	16·2
January 1931	17,375	13,578	30,953	560	25·5	438	14·1	998	18·5
February 1931	14,496	12,131	26,627	518	23·5	433	14·4	951	18·3
March 1931	15,900	12,216	28,116	513	22·3	394	14·1	907	17·8
April 1931	16,188	11,383	27,571	540	23·5	379	14·0	919	18·4
May 1931	17,772	12,950	30,722	573	22·9	418	13·5	991	17·7
June 1931	16,955	12,291	29,246	565	22·6	410	12·8	975	17·1
Total	183,601	151,372	334,973						
Average yield	15,300	12,614	27,914	503	20·7	415	13·0	918	16·3
Average for 1929-30	25,846	10,675	36,521	851	20·1	351	12·4	1,202	17·0

Appendix III.

Statement showing the average yield per day and per cow per day of the Sahiwal cows for the last ten years (from 1921 to 1931).

Year	Average number of cows in milk per day	Average yield per day	Average yield per cow per day
		lb.	lb.
1921-22	59	558	9·7
1922-23	47	521	11·0
1923-24	44	536	11·9
1924-25	44	491	11·1
1925-26	32	388	12·3
1926-27	39	455	11·7
1927-28	37	466	12·7
1928-29	28	398	14·3
1929-30	28	351	12·4
1930-31	32	415	13·0

Appendix IV.

Statement showing the disposal of cattle during the year 1930-31.

Number of animal	Description	Total price	Average
		Rs.	Rs. A. P.
7	Montgomery cows	233	33 4 7
12	Cross-bred cows	1,735	144 9 4
2	Montgomery heifers	45	22 8 0
14	Cross-bred heifers	1,290	92 2 3
7	Montgomery young bulls	850	121 6 10
34	Cross-bred steerlings	1,250	73 8 6*
6	Montgomery draught animals	475	79 2 8
1	Ayrshire bull	500	500 0 0
83		6,378	

* Per pair.

Animals sold on nominal price.

	Rs. A. P.
3 Cross-bred bull-calves	5 4 0
18 Cross-bred cow-calves	90 0 0
2 Montgomery bull-calves	10 4 0
	105 8 0

REPORT OF THE IMPERIAL DAIRY EXPERT.

(William Smith.)

I. INTRODUCTION.

I was in charge of the office of the Imperial Dairy Expert during the year 1930-31 except for three months and twenty-seven days' leave when Mr. Zal R. Kothavala officiated.

Notwithstanding the adverse conditions and the fall in prices of agricultural products, the demands made on this office for technical advice and instruction connected with the dairy industry from all parts of India have not fallen below those of previous years. The financial stringency has held up various schemes drawn up in whole or in part by this office for the improvement of city milk supplies in Chittagong, Dacca, Bangalore and Bombay.

The main experiment at the Karnal Farm, that of determining the effect of dairy conditions on the male progeny of heavy milking dams as field workers, has reached the stage where a number of bulls from the heavier milkers have been castrated and are being reared under normal conditions as work bullocks. When the farm was taken over, the herd consisted of 53 cattle ; to-day there are 685 head of homed stock being supplied with farm-grown fodder, and without reducing its money crop area the farm can easily produce fodder for 1,000 head of cattle by the system of double-cropping introduced in 1928, *i.e.*, by the growing of a *jowar* (sorghum) crop in the monsoon between the harvesting of the one *rabi* (winter) crop and the sowing of the next.

The low-lying land at Karnal is particularly suitable for rice growing, and for the past 22 years a *kharif* crop of rice and a *rabi* crop of wheat have been grown in this land each year. The land is now showing signs of exhaustion. Recent experiments with early maturing varieties of rice have shown that a leguminous crop of peas or gram can be successfully grown in the same cropping year. Hence to see how far fertility can be restored by replacing wheat by a legume, the latter will be tried on No. 7 plot. The yields obtained from the quick-growing rice are less than from the late variety, but the quality is better.

The wheat yield at Karnal during the year under review is one of the poorest on record, due to want of rainfall in the cold season and to a large area of the new Pusa wheat No. 52 being seriously affected by rust. In the previous year with an abundant winter rainfall this wheat did particularly well at Karnal, but this year evidently owing to lack of rainfall the yield was very seriously affected by rust. The other wheat grown on the farm along with Pusa 52, *viz.*, Punjab 8A, showed no signs of rust.

The Botanical Section and the Sugarcane Expert took over 141 acres and 30 acres respectively of Karnal lands as sub-stations.

The flock of pure Bikanir sheep at Karnal continue to thrive and are being bred by careful selection for wool production only. The flock now numbers 243.

The greatly improved financial result of the Bangalore Farm, as compared with the previous year's trading, is due to favourable weather conditions and to the fact that the farm had a number of half-bred heifers coming into milk which have given excellent yields. A large percentage of the Bangalore herd was throughout the year under various nutrition experiments by the Physiological Chemist to Government, and although the necessity for and the value of these experiments is fully recognised, it must be pointed out that they seriously affect the yields of the cattle employed.

For the past six months the Wellington Farm has been free of serious disease outbreak, but in the early part of the year the animals suffered from an attack of rinderpest and from the effects of the previous attacks of foot-and-mouth. The stock at this farm, however, are now in better health and condition than for some years past.

The working of the Research Creamery at Anand continues to be seriously hampered for want of proper equipment, and the service of a chemist with a properly equipped laboratory is urgently required. The decrease in the profits earned at Anand are due to the world-wide fall in butter prices and to decreased demand for butter owing to financial depression.

The Central Bureau of Animal Husbandry dealt with many enquiries received for advice and information on purely cattle-breeding matters, and the slides and films owned by this department were shown at public meetings and demonstrations during the year at Delhi, Calcutta, Dacca, Allahabad and Tiruppur.

II. TRAINING.

No fresh admissions were made to the Indian Dairy Diploma course during the year, as this was the intervening year. The fourth batch of 24 students admitted during the previous year continued their training at the Wellington Institute and the Government Creamery at Anand. Their last term will be spent at Bangalore where they will sit for their final Diploma examination.

The five post-graduate students admitted to the course in January 1930 completed their training during the year, and were awarded the usual certificates. Three students were admitted to the course commencing in January 1931 and are now in training.

Short courses of practical training in different branches of dairying, varying in periods from three to six months, were given at our training farms at Bangalore, Wellington, Karnal, and the Research Creamery, Anand, to ten students from private organizations, Indian States and Provincial Governments.

Mr. T. Y. Watson, a Colonial research scholar in agriculture, was deputed for a course of training in animal husbandry under Indian conditions.

III. EXPERIMENTAL AND RESEARCH WORK.

Investigations were carried out during the year in connection with various problems affecting the dairy industry.

Anand.

In collaboration with the Health Department of the Corporation of Bombay, experiments were carried out—and still continue—to ascertain the best methods of treatment of whole milk to be railed by ordinary train in non-refrigerated wagons from Gujarat, the dairying district of the Bombay Presidency, to Bombay City. One of the difficulties of this traffic is the semi-churning of the milk *en route* and the formation of butter globules on the surface of the cans. The effect of homogenising the milk with an atomising machine in preventing this is under study.

The general idea amongst butter-makers in India that the pasteurising of cream for butter-making alters the consistency and lowers the melting point of butter made from buffalo milk, was examined; the melting point of butter made from pasteurised and unpasteurised cream was tested and little or no difference between the average melting points was found; the difference was not sufficient to affect the table consistency of the butter. Samples of butter from both pasteurised and unpasteurised cream kept for periods of from 1 to 7 days before churning were tested, and the age of the cream made no difference in the melting point of the butter made from it.

Tests of the percentage of casein found in butter made from pasteurised and unpasteurised cream and from butter made from cream kept for periods of from 1 to 7 days before churning were also carried out. The results showed that the keeping of cream for periods beyond the usual ripening period of 24 hours did not appreciably increase the casein percentage and there was little difference in the average percentage of casein as between pasteurised and unpasteurised butter. The above tests were made with the help of the Chemistry Section at Pusa, and it is hoped to carry them out on a larger scale for confirmation.

Karnal.

A preliminary investigation was made to ascertain the difference in live weight and milk yield of the second generation of the two Indian breeds of cows kept there as compared with their dams. The results from the few animals available which had completed a second lactation showed increases both in weight and milk yield when compared with their actual dams.

An investigation in the correlation of yields with age and live weight of selected Hariana and Thar Parkar cattle showed, as was expected,

that animals of average weight (750 lb. to 900 lb.) in the case of Thar Parkar and 9,00 to 10,00 lb. for Hariana and in the prime of life (7 to 9 years) gave the best results.

An investigation on the effect of seasonal calving on milk yield showed that the spring calvers gave the best average yields, whilst those animals calving in August gave the poorest average yields ; and a further investigation as to the average time required by Hariana and Thar Parkar cows to reach maximum yield after the date of calving showed that both breeds reached their maximum in from three to four weeks of calving, the actual figures being 26·8 days for the Thar Parkars and 24·4 days for Hariana cows.

An examination of the farm records for the year shows that both Hariana and Thar Parkar cattle are breeding regularly ; the serving records show that, without allowing for abortion, slipping of calf and failure to hold, the milking animals of both breeds should calve yearly, serving dates on the average being 2 months 16 days after calving.

A study of the effect of homogenising milk at full pressure showed a very slight loss in fat percentage by the Gerber test, and also demonstrated that it was quite impossible to separate the cream from the milk so treated either by mechanical means or the force of gravity.

Bangalore.

An experiment was carried out to determine variations in the quality and quantity of milk yielded by different quarters of the udder. Six average healthy Scindi cows in full milk were used and the results may be summarised as follows :—

The front right quarter teat and the left hind quarter teat gave 13·9 per cent. more milk than the other two teats. The two hind quarter teats gave an average of 22·1 per cent. more milk than the two front quarter teats. The right quarter two teats yielded 12·5 per cent. more milk than the left quarter ; the milk from all four teats being separately recorded in each case, the fat percentage did not differ but was the same from all four teats.

The result of investigations as to the loss of milk in pasteurising at Bangalore published in the *Journal of the Central Bureau for Animal Husbandry and Dairying in India*, Volume IV (1930), shows that the normal shrinkage in the pasteurising of small quantities of milk should not exceed 1·12 per cent.

An enquiry into the dry period of Scindi cows of all ages showed that the maximum dry period was 314 days and that one Scindi cow took the bull 25 days after calving. The average dry period was 117·2 days, quite a reasonable figure for pure Indian cattle. Further investigations on Scindi cows showed that the reduction in yield of milk due to oestrom was small, the average decrease being some 10 oz. only. The effect of seasonal calving amongst Scindi cows does not agree with the Karnal results ; generally speaking, the Scindis at Bangalore do equally well

no matter what time of the year they calve. A comparison of the yields of all farm-bred Scindi cows at Bangalore with days in milk and dry period goes to show that the most profitable cow of this class, or indeed of any class for India, is the regular calver with a dry period of from 90 to 120 days.

IV. ADVISORY WORK.

Bombay Presidency.—The Veterinary Surgeon of Cutch State (Mandvi); the breeding of the local Gir breed of cows with the Jersey, and the feeding of concentrates to milch cattle.

The Superintendent, Shree Ranchhodrayjee Gowsala, Dakore (Kaira District); the method of feeding *jowar* to milch cows and the treatment to be given to cows to bring them to heat.

The Secretary, Shri Govardhan Sanstha, Gorakshana Karyalaya, Poona; the best breeds and purchasing centres of Indian cattle for milk yield and draught; the prospects of extending the dairy industry in the Deccan and the areas most suitable for that purpose; the elimination of buffaloes from the dairy industry.

The Economic Botanist to the Government of Bombay; the method of classifying grass lands in India, their value and utilisation, and lines of improvement.

Bombay City.—The Municipal Commissioner; the municipal control of the city milk supply. Messrs. Durant and Meighiji; the establishment of a proposed dairy farm at Bombay. Messrs. Bhiladwalla, Patel and Polson; regarding their respective milk supply schemes. Messrs. Duncan Stratton & Co.; establishment of a *ghee* (clarified butter) factory in India. The Health Officer and the Municipal Analyst; difficulties connected with transport of milk from Gujarat. Messrs. Polson's; the improvement of butter put up for sale. Mr. M. D. Darookhanavala; transport of milk from Charotar into Bombay city for retail distribution. Messrs. Polson Manufacturing Co.; the transport, refrigeration and organisation of the daily milk requirements of Bombay City. The Provincial Honorary Secretary, the Bombay Public Milk Association; frequent curdling of milk supplied from out-stations between Bassein Road and Bulsar; (1) milk to be produced under sanitary conditions, (2) pasteurisation before despatch, (3) transport in refrigerating vans and insulated cans, (4) distribution in Bombay city immediately on arrival for consumption.

In addition, advice was supplied to firms, public bodies and individuals at Anand, Sabarmati, Dakore, Sangli, Poona, Broach and Atkot (Kathiawar).

Punjab.—The Superintendent, Government Cattle Farm, Hissar; the latest method of making *ghee*, the system of tatooing cattle for identification.

Mr. Dost Mohamed Khan of Jehangirabad Farm; the best means of disposing of his milk supply.

Mr. Shambhudial Kagzi, Honorary Secretary of Rewari Gowsala, Rewari; the purchase of bull-calves from the Imperial Cattle Breeding Farm, Karnal.

Dr. J. L. Sarim, Officer on special duty, Department of Industries, Punjab, Lahore; a complete scheme for starting a dairy farm with a foundation stock of 75 cows and 25 buffaloes in the Punjab, with cost and particulars of buildings and machinery and the trading results for the first year's work.

The Director of Agriculture and Gardens, Kapurthala State; the cream and butter ratios per cent. in the milk of cows and buffaloes.

Mr. P. P. Gupta of the Delhi Cattle Breeding Farm, Delhi; the correct temperature of milk to be delivered for the use of infants.

Mr. P. N. Sud, Kailash Dairy Co., Ludhiana (Punjab); the best method of packing butter for despatch over long distances in India, in all weathers, so that the firmness of butter may be retained without the addition of any preservatives.

Mr. Gajindar Singh of Mouzang, Lahore; markets for casein in India and in England.

Rajputana.—At the request of the Mewar Durbar, this office took part in the Agricultural and Educational Exhibition held at Udaipur, 1930, and arranged for a demonstration of modern methods in dairying by cinema films, posters, lantern slides and actual exhibits of dairy products of our farm at Karnal and the creamery at Anand, with a view to popularise our dairy products besides educating the public in the most up-to-date methods of dairy farming.

The Manager of the Bundi Agricultural Syndicate, Ltd., Bundi State (Rajputana); type of cows developing plough cattle and increasing the supply of manure.

The Director of Agriculture, Jodhpur; plans and estimates showing the lay-out of a small dairy farm.

Kashmir.—Mr. H. Hasland-Christensen of Srinagar; the source of supply of young bulls and heifers of the English Shorthorn breed in India, for the use of the Chinese General Governor of Eastern Turkestan.

Mr. N. N. Koul, I.D.D., of Suthoo—Srinagar; scheme for the supply of milk to the Srinagar city.

In addition, advice was supplied to firms, public bodies and individuals at Jehangirabad, Rewari, Ambala, Jullunder, Lahore, Kapurthala, Delhi and Ludhiana.

Bengal.—The Express Dairy Co., Ltd., Calcutta; the daily average yield of milk of Multani and Hissar breeds of cows.

Mr. B. C. Roy of Calcutta; scheme for starting a dairy farm with an initial capital of Rs. 1,000 in a suburb of Calcutta.

Mr. T. J. Sangal of Bina Dairy Farm, Nazirganj (Bengal); the best method of improving the keeping qualities of milk for despatch from Nazirganj to Calcutta.

The Superintendent, Co-operative Societies Milk Union, Calcutta; the feeding of a bull which had a disinclination to serve, elimination of smoky taste in butter prepared from cream collected from co-operative societies, and a detailed specification of plant and machinery amounting to Rs. 10,000 for a co-operative dairy factory at Chittagong.

The Director of Industries, Bengal; the manufacture of condensed milk, malted milk or milk powder in India, and the approximate cost of a modern milk condensing plant with buildings, etc., required for the construction of the plant.

The Director of Agriculture, Bengal; purchase of bulls.

In addition, advice was supplied to firms, public bodies and individuals at Calcutta, Jhantipahari, Kalna, Jharia and Kakailseo (District Sylhet).

Madras.—Sowcar Ghanshamdas Narayandas, Member, Hindu Devastanam Committee of Trichinopoly; note on the working of the *pinjrapoles*.

Professor Avod of Masulipatam; the percentage of salt to be added to butter.

Mr. G. Veharid, Veterinary Assistant Surgeon, Berar; the cost of first class Punjabi buffaloes, cost of buildings to house them, cost of feed and attendance and approximate daily yield, etc.

Mr. R. Brhmabadhry of Masulipatam; the average percentage of butter fat in the milk of cows and buffaloes and the percentage of *ghee* from butter.

Mr. V. S. S. R. Sarma, Public Accountant and Auditor of Rajahmundry; project for a milk-producing business. He was informed that grazing land to produce 75 per cent. of the fodder and to properly exercise the cattle, was necessary.

Mr. M. Narayana Rao, Vakil, Karkala, South Canara; the best type of cattle suitable for the West Coast of India.

The Deputy Director of Agriculture, Hosur Cattle Farm; selection, branding and despatch of ten young Scindi Murra buffaloes for the use of the Government Buffalo Farm at Guntur.

The District Veterinary Officer, Nellore; the treatment of cattle suffering from loose and split horns which was prevalent amongst Ongole cattle at Government farms at Chintaldevi and Hosur.

To a query from the Military authorities whether the Bangalore Institute was in a position to supply dairy produce to the troops and Military hospitals in Madras and St. Thomas Mount, this office pleaded inability to cope with the supply owing to financial considerations. The subject is still under correspondence with the Military authorities.

Mysore State.—Mr. V. G. Janardana Rao, I.D.D., of Mysore; criticism of a plan of a combined dairy and dwelling house.

Hyderabad State.—At the request of the Hyderabad Durbar, I visited Hyderabad and attended a meeting convened by the Director-General,

Commerce and Industries Department, and advised as to the best type of animals to be purchased for milk supply and to breed improved types of bulls. I also helped the agricultural officers of the State in the purchase, selection, branding and despatch of the foundation stock of Krishna Valley cattle and gave detailed advice in connection with the type of dairy buildings, water supply and requisite dairy machinery to be erected on the model dairy farms which were in the course of construction.

I gave a public lecture on "City Milk Supply" in Hyderabad City, presided over by Maharaja Sir Kishen Pershad, President of the Council of Ministers in the Durbar.

Mr. A. B. Collins, Director-General, Commerce and Industries Department; a note on the milk supply problem of Hyderabad City.

Travancore.—Mr. P. Kurian John of Kottayam (Travancore); small milking machines suitable for country cattle on small cottage farms.

In addition, advice was supplied to firms, public bodies and individuals at Bangalore, Mysore, Coimbatore, Trichinopoly, Gudlavallera (Kistna District), Vizianagram, Karkala and Kurchipalla (South Canara), Cochin, Coonoôr and Secunderabad.

United Provinces.—Mr. Kumar Rajendra Singh of Rath P. O. (Hamirpur District); a standard plan of dairy buildings to enable him to start a dairy on up-to-date lines.

Messrs. S. Parrot & Co., Allahabad; the class of buffaloes suitable for starting a dairy industry and the cost of installing a refrigerating plant.

The Deputy Director of Agriculture in charge Cattle Breeding Operations, Muttra; an improved type of *ghee* boiler.

The Dairy Manager and Professor of the Agricultural Institute, Allahabad; the after-effects of foot-and-mouth disease in breeding bulls, criticism of a scheme for a milk survey of the city of Allahabad.

Mr. Gopi Nath of Lalkua Junction (R. and K. Railway); the danger of using milk and its products produced from animals suffering from rinderpest.

In addition, advice was supplied to firms, public bodies and individuals at Agra, Cawnpore, Bulandshahr, Allahabad, Naini Tal, Rath (District Hamirpur), and Palmandi (Dehra Dun).

Bihar and Orissa.—The Officiating Imperial Agriculturist, Pusa; details of construction and cost of making a non-slip floor for the cattle byre.

The Sanitary Officer, Putki P. O., Kusunda (Manbhum); the result of feeding oily food such as cotton-seed to milch cattle.

The Deputy Director of Agriculture, Chota Nagpur Range, Kanke (Ranchi); preservation of milk in Frigidaire chambers used in hospitals.

Mr. J. K. Dholakia, Mining Engineer, Ballihari, Kusunda P. O., the effect of feeding concentrates containing excess of fatty matter to milch cattle on the fat-content of the milk.

Central India.—Mr. H. T. Gogate of Indore City ; scheme for a model dairy company and co-operative organization of the village milk producers.

The Live-Stock Officer, Dhar State ; the breeding policy to be pursued within his State.

Burma.—The Officer Commanding, the British Military Hospital, Maymyo ; the best type of pasteuriser for use in Burma for a dairy with 300 cows.

Foreign Countries. Mr. J. A. Gilruth, Chief of Division of Animal Health, East Melbourne, Australia ; the protection against surra which can be afforded to cattle prior to their desptach from India into Australia. He was informed that this office was prepared to undertake the selection and despatch of cattle, if necessary.

Mr. Chas. F. Woodhouse of Massachusettes (U. S. A.) ; the average annual yield of an Indian good class cow, best milking breeds in India, and their approximate cost and the scale of rations used at the Imperial Cattle Breeding Farm, Karnal.

Articles written.—I contributed an article on " Dairy Farm Buildings in India " for the Imperial Council of Agricultural Research which will be published in the Dairy Journal.

I added a foreword to the following article :—

" Statistical Studies of records of Indian Dairy Cattle " by Mr. Lall Chand Sikka of Agricultural College, Lyallpur (Punjab).

V. KARNAL, BANGALORE AND WELLINGTON FARMS AND ANAND CREAMERY.

Karnal.

The farm has 2,154 acres, of which 333 were under direct home cultivation, 383 on cash rental and 690 under *batai* (share system), and the balance, 748, being grazing areas, roads and buildings. The chief crops grown, as in other years, were wheat, gram, rice and *jowar*. As mentioned in the introduction, the rice area will be sown with peas and gram after the early variety of rice instead of the previous practice of sowing wheat after the late variety of rice. The yields from the farm were low, due mainly to want of rain, and, in addition, to rust attacks on the wheat.

The farm started the year with 689 cattle of all ages and 201 sheep and finished the year with 686 cattle and 243 sheep. 153 calves were born, 41 heifers calved, 38 cattle of all classes died, of which 25 were calves under 1 year, and 160 animals were sold. The mortality amongst calves has been greatly reduced by the construction of cement floor which can be properly washed and disinfected. The farm still maintains 3 breeds of cattle and a flock of sheep. The adult herd comprises 108

Thar Parkars, 84 Harianas and 32 buffaloes, and the results as regards yields are very promising. This year 76 Thar Parkars completed a lactation period giving an average of 2,805 lb.; 14 gave over 4,000 lb., of which 8 were farm-bred. Sixty-five Harianas completed a lactation during the year averaging 2,464, of which 7 were over 4,000, the best being a farm-bred which yielded 6,463 lb. Twenty-three buffaloes completed a lactation giving an average of 4,398 lb., of which 12 were over 4,000, 4 being farm bred. Below is a statement which will show the improvement :—

Year	Thar Parkar	Hariana	Buffaloes	Remarks
	lb.	lb.	lb.	
1927-28	1,965	1,905	8,278	Few cattle.
1928-29	1,800	1,950	3,600	
1929-30	2,426	2,329	3,763	
1930-31	2,805	2,464	4,398	

The yield is steadily improving, but the object of the farm is to produce a dual purpose animal—milk and draught. To test whether efficient draught animals can be got from a heavy milk producer, 16 calves of both breeds have been picked from heavy milkers. These calves will be reared in exactly the same way as the other calves and will be castrated when 18 months old, and when old enough they will be tested for draught.

The following table shows the yield of six principal cows of the Thar Parkar and Hariana breeds and Murra buffaloes which completed their lactation period during the year :—

Thar Parkar cows.

No. of animal	Approximate age or date of birth	Milk yield 1930-31	Days in milk	Remarks
		lb.		
71	13 years . .	6,057	477	Weaned.
119	13 „ . .	5,708	325	„
126	13 „ . .	5,570	375	„
251	2nd April 1925 .	5,361	462	Weaned (farm bred).
256	23rd August 1925 .	5,159	658	„ „ „
272	7th June 1925 .	5,019	408	„ „ „

Hariana cows.

No. of animal	Approximate age or date of birth	Milk yield 1930-31	Days in milk	Remarks
		lb.		
110	4th May 1921 .	5,371	387	Weaned (M. D. F.).
142	10 years . .	5,727	295	,,
170	11 ,, . .	4,502	361	,,
267	9 ,, . .	5,645	549	Not weaned.
268	9 ,, . .	4,589	549	,, ,,
302	7th April 1926 .	6,463	399	Weaned (farm bred).

Murra buffaloes.

No. of animal	Approximate age or date of birth	Milk yield 1930-31	Days in milk	Remarks
		lb.		
4	12 years . .	6,464	495	Weaned.
15	12 ,, . .	5,349	326	,,
16	12 ,, . .	5,072	295	,,
25	10 ,, . .	7,628	546	Not weaned.
29	10 ,, . .	6,158	320	Weaned.
37	21st August 1926 .	6,275	555	Weaned (farm bred).

Sales of stud bulls were very disappointing due no doubt to the financial position.

The Muktesar staff inoculated 149 cattle by the serum simultaneous method.

Bangalore.

Lands and cultivation. The rains during the year under review were very satisfactory with the result that the outturn of green fodder was 14 per cent. in excess of last year, and consequently no green fodder for silage was purchased as in previous years.

Herd. The yields of the six principal cows in the cross-bred and Sindi groups are shown in the following table :—

Cross-bred cows.

No. of cows	Date of birth	No. of calving	Quantity of milk given in lb.	No. of days in milk	Remarks.
523	24th Jan. 1916 .	11	9,644	448	Half-bred.
420A	2nd Oct. 1925 .	3	11,174	332	,, (3rd lactation).
766	25th Sept. 1916 .	10	6,974	460	¾-bred.
353A	9th Nov. 1921 .	5	9,859	407	,,
975	4 th Feb. 1919 .	9	7,422	375	Half-bred.
379A	8th May 1922 .	5	7,387	334	,,

Scindi cows.

No. of cows	Year of purchase and present approximate age		No. of calving since arrival	Quantity of milk given in lb.	No. of days in milk	Remarks.
	Year	Age				
96	1925	5	2	4,027	255	Farm bred.
124	1928	13	2	3,641	302	
142	1928	10	2	4,294	257	
148	1928	10½	2	6,352	428	
149	1928	7½	3	3,890	255	
137	1928	7½	2	3,919	298	

During the year the farm herd produced 581,413 lb. of milk which was supplemented by a purchase of 32,488 lb. mainly for feeding the calves. 387,349 lb. of new milk were sold to British and Indian Military Hospitals, officers, civilians and troops at an average rate of Rs. 0-2-11 per lb. From the milk produced at the Institute 121,030 lb. were separated, out of which 9,541 lb. cream were made. Out of this cream 3,429 lb. were sold as such, 6,113 lb. were converted into butter, the outturn being 3,563 lb. ; 9,300 lb. milk were used for the manufacture of cheddar cheese, the outturn being 769 lb. 111,489 lb. separated milk were produced, of which 108,981 lb. were issued for feeding the calves and 2,165 lb. sold. Out of the balance certain quantities were used for starter, etc.

During the year there was no alteration in the price of milk, and the Institute was able to meet fully the requirements of the Military, besides many civilian customers. No purchased milk was, however, utilised for resale.

Breeding policy. There has been no change in the policy, which is briefly :—

(*a*) Best Scindi cows bred to selected Scindi bulls.

(*b*) Other Scindi cows are bred to imported bulls, either Ayrshire or Friesian.

(*c*) Half or three-quarter bred cows are crossed by Indian bulls of a known milking strain, generally a Sahiwal bull.

Wellington.

The rainfall during 1930-31 was 10 per cent. less than in the previous year.

The yields of different crops obtained during this and previous year are shown below :—

	1930-31		1929-30	
	lb.		lb.	
Maize	20,800	48 acres	1,34,675	52 acres
Jowar (sorghum)	1,16,710		88,075	
Oats	1,38,790		1,91,420	
Lucerne	6,475	¾ acre	7,595	1 acre
Green mustard	..		1,410	
„ grass	1,16,020		1,70,400	
„ bedding	11,155		61,270	
Oat hay	..		8,275	
Total fodder lb.	4,09,950		6,63,120	
Potatoes	57,010	11 acres	1,18,214	8 acres
Total outturn	4,66,960		7,81,334	

The policy of the farm is to produce as much fodder as possible to supplement purchases.

Herd. The different classes and breeds maintained in the herd were :—Ayrshire, 8 ; Jersey, 1 ; Ayrshire-Jersey, 1 ; Ayrshire-Scindi, 15 ; Ayrshire-Hansi, 2 ; Ayrshire-Sahiwal, 10 ; Ayrshire-Thar Parkar, 1 ; Ayrshire-Scindi-Sahiwal, 4 ; Half-bred × Half-bred, 1 ; ¾-Ayrshire-Jersey, 1 ; ¾-Ayrshire-Scindi, 1 ; ¾-Ayrshire-Hansi, 1 ; Holstein-Hansi,

2 ; Scindi, 4 ; Hariana, 13 ; Sahiwal, 1 ; Ayrshire-Sahiwal-Sahiwal, 1 ; Ayrshire-Hansi-Sahiwal, 1 ; $\frac{3}{4}$-Ayrshire-Sahiwal, 1 ; Sh.-Scindi-Sahiwal, 1 ; $\frac{1}{4}$-bred, 1.

The condition of the herd was not satisfactory and emphasised the need for a proper cattle hospital. Some of the animals suffered from the after-effects of foot-and-mouth disease, which affected not only the milk yield but caused the death of six and the unexpected abortion of 13 cows. As a result 72,740 lb. of milk had to be purchased from outside sources. There was also an outbreak of rinderpest ; three of the best Ayrshire cows and one Ayrshire bull were lost, and the condition of other animals deteriorated. To replace casualties and condemnations during the year, 16 cows were purchased from Karachi, and 8 cows were transferred from the Agricultural Section, Pusa.

The best yields of six pure-bred and six cross-bred cows obtained during the year are given below. They are much below previous year's owing to the illness already mentioned.

Pure breds.

No. of cow	Quantity given	In what period
	lb.	Days
21	7,087	397
20	4,547	356
3	4,481	344
17	4,108	247
16	3,004	367
7	2,952	306

Cross-breds.

200	7,654	385
709	7,053	497
100	5,680	348
99	5,603	307
123	5,320	594
101	5,211	320

The value of produce sold in the present and preceding year is given below :—

	1930-31		1929-30	
	Quantity	Amount	Quantity	Amount
	lb.	Rs.	lb.	Rs.
Milk	248,064	48,211	239,865	46,525
Butter	19,329	28,108	19,286	28,271
Cream	434	760	619	1,084
Cheese	72	126	85	146
Butter milk	117	2	2,613	41
Separated milk	146	9	101	7
Sundry credits	..	59	..	148
TOTAL	..	77,275	..	76,222

ANAND.

The trading results of the Creamery on its commercial side showed a reduced profit of Rs. 8,698-8-5 against Rs. 13,807-7-0 in the preceding year, owing to reduced sales and the fall in prices.

Comparative figures of sales for this and last year are given below :—

	1929-30		1930-31	
	lb.	oz.	lb.	oz.
Butter	80,395	12	70,868	4
Ghee	6,476	2	2,757	12
Casein	13,915	4	27,348	0
Separated milk	445,625	0	177,596	0
Whole milk	360	0	..	
Cream	44	7	29	2
Cheese	38	12	69	0
Butter milk	..		3,985	0

Experiments and demonstrations. This work is seriously hampered by the absence of a laboratory and the services of a research chemist.

Experiments in the transportation of pasteurized whole milk to Bombay were carried out through the Executive Health Officer, Bombay Municipality, Mr. Raojibhai B. Patel, late Agricultural Adviser to Baroda State, and other interested agencies.

The keeping quality of milk pasteurized in Gujarat and transported to Bombay was carefully noted. It is anticipated that this experiment will be successfully concluded during the current year as a modern homogenising plant has been installed and the process of homogenisation will prevent the cream coming to the top of milk.

REPORT OF THE PHYSIOLOGICAL CHEMIST.

(F. J. Warth, M.Sc.)

I. CHARGE.

I held charge of the Section throughout the year.

II. LABORATORY WORK.

The following is a list of analyses completed during the year :—

Complete analyses :—		
1. Fodders	89	
2. Fæces	115	
		204
Partial analyses of fodders		19
Dry matter in fæces, urine, fodders, etc.		2,319
Single nitrogen determinations in fresh fæces, fodders, urine, etc.		791
Mineral analyses of soils, urine, fodders, etc.		191
Partial mineral analyses		32
Complete analyses of urine		249
Miscellaneous analyses		470
Total		4,275

III. WORK OF THE SECTION.

1. Experiments on nutrition of growing animals.

A feeding experiment to compare the merits of single and mixed fodders has been carried out. Three groups of heifers received respectively hay, *ragi* (*Eleusine coracana*) straw and a mixture of these two fodders. Concentrate and a small allowance of green food were given to all alike. The following table gives a brief summary of the food consumed and live-weight increases obtained on the three types of rationing.

Summary of the experiment with heifers.

	Daily average food consumption per head in lb.				Average live weight	Total live weight increase
	Roughage	Guinea grass	Concentrates	Total		
Group A. *Ragi* straw	6·62	1·64	2·95	11·21	494·0	77·0
Group B. Mixture	7·58	1·64	2·94	12·16	489·0	80·0
Group C. Hay	8·04	1·64	2·95	12·63	489·0	86·0

There are two points of interest in these figures. Firstly with regard to the merits of the mixed fodder it is seen that the consumption was slightly greater than the mean of the two fodders given separately. It has to be concluded, however, that in this respect the advantage of mixing is scarcely perceptible. There is no doubt that experiments of this kind must be carried out for much longer periods to bring out other advantages which may reasonably be anticipated.

The second point of note is the consumption of the fodders fed singly. From the beginning to the end of the experiment hay was invariably consumed in much larger amount than *ragi* straw. At first this was attributed to the greater palatability of the hay. Later laboratory experiments have however brought to light the interesting fact that *ragi* straw when wetted swells in a remarkable manner. It seems highly likely therefore that consumption of this fodder is limited by the swelling which occurs after ingestion. Another feeding test with heifers has been commenced to collect further information on this point.

2. Experiments on milk production.

An experiment on silage rationing for cows in milk has yielded some interesting data. With regard to silage consumption it was found that, even when a considerable excess was fed, the average animal could not consume more than 8 lb. dry matter per day, whilst over a long period the average consumption was 7·3 lb. dry matter per day which corresponds roughly to 29 lb. fresh silage daily. One group of cows was fed in this way ; another group was fed on a limited amount of silage. For dry fodder *ragi* straw was provided to both groups *ad lib.* Concentrate was given in proportion to milk yield. The data obtained in this experiment, which covered a period of 100 days, are briefly summarised in the accompanying table.

Summary of the experiment with cows.

	Daily average food consumption per head in lb.				Total milk yield per head in lb.	Total fat yield per head in lb.	Total protein yield per head in lb.	Average live weight	Total live weight increment
	Silage	*Ragi* straw	Concentrate	Total					
Group A .	7·34	5·05	9·14	21·53	1,693·02	68·06	46·76	789·3	35·1
Group B .	4·33	7·03	9·31	20·67	1,753·86	68·51	47·02	777·3	21·7

The experiment shows that, when necessary, the silage ration, which is expensive to make and feed, may be reduced to 17·2 lb. a day if other suitable roughage is provided. On the reduced silage ration the milk yield was well maintained over a period of 100 days. It was found that the animals made up almost completely for the shortage of silage by eating more *ragi* straw. In this experiment it was found also that milk was produced at a very economical rate of food consumption.

This favourable result is attributed to the fact that all the fodder was fed in a chaffed state. The value of chaffing, which seems to be emphasised by this trial, is certainly deserving of attention. Accordingly further experiments to test the practical value of chaffing have been commenced at Bangalore. Further work which is proceeding on milk production comprises comparative experiments with oil-cakes, on lines described in previous reports.

One point brought out by the above table is that Group B gave a higher yield of milk but less live weight increase than Group A. This suggests that the ration of Group B is more efficient in milk production, and less efficient in promoting live-weight increase, than that fed to Group A. Although Group B received, naturally, more concentrate than Group A, the latter amount was small and the results suggest that the bulk of the difference in milk yield and live-weight increase is to be ascribed to the relative proportions of silage and *ragi* straw in the two rations. It is hoped to make a more detailed and rigid examination of this at a later date.

3. Indian coarse fodders.

It was noted in last year's report that the digestibility of the carbohydrates of fodders is at times depressed in an exceptional manner. This question seems to be important and is receiving attention from two points of view. In the first place more varied samples are being collected from the areas where this depression was noted. Digestion experiments will be carried out with these samples. In the second place the carbohydrates of these fodders are being studied.

The main work on coarse fodders during the past year has been a study of the nitrogen balance with two typical fodders. During a long series of tests the protein content of the ration was changed at intervals, the nitrogen balance being determined at each stage. Extensive data on food consumption and live-weight changes were collected at the same time. The experiments indicate that the nitrogen balance is influenced by the nature of the fodder, that is to say, the maintenance requirement of protein is likely to vary according to the fodder used. The results of this experiment are being tabulated for publication.

4. Mineral requirements of cattle.

The experiment on mineral assimilation by growing heifers on two characteristic fodders, commenced sometime ago, was unfortunately interrupted by illness in the neighbourhood, necessitating inoculation of all the animals. This class of work is of fundamental importance and schemes for carrying it out under more satisfactory conditions are being considered. The main difficulty arises from the fact that the test has to be continued for a long time. Three years is probably the minimum period for assessing the mineral requirements of growing cattle.

Mineral assimilation from selected fodders has also been studied in a long series of experiments with bullocks. Under the conditions employed losses of lime and phosphoric acid have been noted. The losses have varied according to the fodder used. This experiment is now in its second phase in which the influence of mineral supplements is being tested.

Under this head may be mentioned an experiment on iodine feeding to calves which has yielded some interesting results. Of the animals receiving iodine only one had a slight attack of indigestion, whilst among the controls receiving no iodine seven animals suffered from intestinal complaints and two of them died. Iodine was also found to reduce attacks of ringworm and mange.

5. Indian pasture grasses.

As reported last year, samples for this enquiry are being produced at a number of typical stations. The work is proceeding satisfactorily.

6. Silage investigations.

On the subject of ensilage of green *juar* (sorghum) two papers have been submitted during the past year. In the first paper the changes occurring during normal filling were studied. This work largely corroborates what has been found by other workers in India. The second paper deals with methods of filling. It has been shown very clearly that the largest quantity of good silage is obtained by slow filling accompanied with moderate watering. The experiments are useful in showing the extent of loss that may occur when filling is done more rapidly and when water is not added.

Continuing the work on silage making from cereal straws, this year silage has been prepared from rice straw and tested with heifers. The material was consumed greedily daily for a period of two months and judged by aroma and appearance it was an excellent brown silage. The aim in these cereal silages is not so much to enhance the nutritive value but rather to provide succulent and tasty food during periods of dry weather. The rice straw silage produced this year was examined by Mr. W. Smith, Imperial Dairy Expert, who immediately advised its use on one of the farms in his charge.

7. Physiological studies.

(*a*) *Hippuric acid excretion.* The various aspects of this question which are receiving attention were detailed in last year's report. The main work during the present year has been devoted to a study of the influence of hippuric acid excretion on the nitrogen balance. The data obtained certainly show that the nitrogen balance is more difficult to maintain when there is high excretion of hippuric acid, but there seem to be other factors complicating the issue. At present a definite statement on these experiments cannot be made.

(*b*) *The acid base balance.* Tentative experiments on the acid base balance of fæces have been carried out and blood tests are now contemplated.

(*c*) *Sulphur metabolism.* A certain amount of evidence has been obtained which indicates that urinary phenols may influence the sulphur metabolism of cattle. Work under this head has been made more precise by the construction of a new form of apparatus for the determination of sulphur in fodders. By employing improved methods it has been found that a large proportion—as much as two-thirds—of the total sulphur in some fodders exists as inorganic sulphate. This is a significant fact in work on sulphur metabolism.

IV. CO-OPERATION WITH OTHER DEPARTMENTS.

(1) *Military Farms Department.* During the year under report the experiment at Kirkee on rationing for milk production was brought to a conclusion. The results of this work are being tabulated.

(2) Other co-operative work has been suspended for the present, but, at the request of the Department of Agriculture, Bombay, a scheme for joint work with the Bombay Department is under preparation.

(3) In the work on pasture grasses, the Section is receiving help from Pusa, and also from the Madras, Bombay, Bengal and Bihar and Orissa Departments of Agriculture.

It should be mentioned here that the Mysore Department of Agriculture has also given very generous help to the Nutrition Section in various ways, particularly in lending us animals which we were not in a position to procure.

V. PUBLICATIONS.

The following papers were published during the year under report :—

1. The influence of Foodstuffs on the Acid-base Balance of Cattle Urine, by F. J. Warth and N. Krishna Ayyar *Biochemical Journal*, Vol. XXIV, No. 6, pp. 1595-1600, 1930.
2. Feeding of Iodine to Young Calves at Bangalore, by T. Seshachalam Naidu, *Agriculture and Live-stock in India*, Vol. I, Part 3, May 1931.

The following papers have been submitted for publication :—

1. Silage Investigations at Bangalore, II. Quality and Yield of Silage in Relation to Filling Conditions, by T. S. Krishnan.
2. Experiments on Rationing of Silage to Cows, by the Post-graduate Students in the Animal Nutrition Section.
3. A Feeding Experiment to Compare the Merits of Single and Mixed Fodders, by the Post-graduate Students in the Animal Nutrition Section.

VI. PROGRAMME OF WORK FOR 1931-32.

Major subjects.

1. Experiments on the nutrition of growing animals.

2. Experiments on milk production, a continuation of the work reported this year.

3. A study of Indian coarse fodders, including determinations of maintenance rations and studies of nitrogen and mineral metabolism. This is a continuation of the systematic work already reported.

4. Indian pasture grasses, the special enquiry described in last year's report.

5. Silage experiments.

6. Physiological studies.

Minor subjects.

1. A study of the chemical methods employed in the above enquiries.

2. Preliminary experiments for the initiation of work on other aspects of nutrition.

PLATE II.

INFLORESCENCES OF SUGARCANE × SORGHUM HYBRIDS.

P.O.J. 2725. P.O.J. 2725 × Sugarcane. P.O.J. 2725 × Sorghum. Sorghum.

P.O.J. 2725. P.O.J. 2725 × Sorghum Hybrid No. 50. Sorghum.

REPORT OF THE GOVERNMENT SUGARCANE EXPERT.

(Rao Bahadur T. S. Venkatraman, B.A.)

I. CHARGE AND STAFF.

I held charge of the office of the Government Sugarcane Expert during the year except for about a fortnight when I was on leave.

A Sub-station under Coimbatore control was opened at Karnal with the funds sanctioned by the Imperial Council of Agricultural Research.

II. SUGARCANE×SORGHUM HYBRIDS.

(*a*) Characters of the inflorescence.

In the previous report mention was made of certain leaf and stem characters obviously derived from the sorghum parent. The flowering of certain of the hybrids during 1930 season yielded valuable additional evidence about the genuineness of these hybrids.

(1) *Shape and size.* As is well known, the sugarcane inflorescence is shaped like an arrow and hence the name. The inflorescence of the sorghum parent, on the other hand, develops into an ovoid or ellipseid head. Certain of the hydrids produced sorghum-shaped inflorescences at the tops of sugarcane stems. In the matter of size there were many gradations from the three-foot long arrows of the sugarcane to the about six-inch long earheads of sorghum. Certain of the hybrids produced inflorescences which, though rather different from that of the sorghum parent in shape and size, resembled that of certain American sorghums (Plate II).

(2) *Awned fourth glume.* In the sugarcane parent the fourth glume is awnless. Certain of the hybrids showed an awned fourth glume like the sorghum parent.

(3) *Colour of stigmas.* The stigmas of P. O. J. 2725 and of most cultivated sugarcanes are purple or purplish in colour. Certain of the hybrids showed greenish white stigmas like the sorghum parent.

(4) *Infertile flowers.* All the hybrids that flowered showed either aborted anthers or sterile pollen. Cross-pollinations with other healthy sugarcane pollen suggested infertility in the pistils as well. This is unfortunate, as it precludes the possibility of further crossings with these hybrids.

(*b*) Cytological studies.

The flowering of the hybrids during the 1930 season enabled the examination of chromosome numbers in the pollen mother cells. Dr. G. Bremer of the Proefstation Java, after examining material sent from Coimbatore, has stated that in one of the two specimens sent the somatic number is what one should expect in such hybrids. My Station is, at present, not sufficiently equipped for such work.

(*c*) Abnormalities.

The hybrids exhibited quite a large number of abnormalities in the leaves, stems and flowers. Certain of these are (1) chlorophyll deficiency in the leaves, (2) twisted and mis-shapen stems, (3) suppressed inflorescences, (5) single or more than two stigmas against the usual two of the cane, and (6) multiple ovaries.

(*d*) Rarity of useful types.

It is widely admitted that useful combinations are by no means too common in cane seedlings. These were found to be rarer still in these hybrids, quite a large number of them not growing very much from the ground. These hybrids would therefore need to be raised in very large numbers for economic results.

(*e*) Juice characters.

Under Coimbatore conditions P. O. J. 2725 has often analysed over 19 per cent. sucrose in the juice at the end of 12 months and the sorghum parent about 4·5 per cent. sucrose at the end of five months. The more vigorous of the hybrids which alone were analysed yielded satisfactory juices at maturity. The juice analyses of some of the hybrids which matured in six months are given below :—

Table I.

Juice analysis of sugarcane-sorghum hybrids, six months old.

Seedling No.	Brix Per cent.	Sucrose Per cent.	Glucose Per cent.	Co-efficient of purity
Co. 351	20·42	18·53	0·17	90·8
Co. 352	19·31	17·33	0·26	89·6
Co. 353	19·01	16·75	0·42	88·1
Co. 354	18·38	16·18	0·41	88·0
Co. 355	17·71	15·22	0·58	85·9
Co. 356	18·51	16·11	0·50	87·0
Co. 357	20·15	18·00	0·18	89·3

(*f*) Gur or jaggery.

Fair quality *gur* or *jaggery* (unrefined sugar as consumed in India) was obtained from laboratory samples of the juice. The available material from these hybrids was too limited for large-scale tests.

(*g*) Second season work.

During the 1930-31 season the hybridisation was effected on a large scale, a whole plot of P. O. J. 2725 being carefully isolated for this purpose. The seedlings obtained—over 75,000 in number—are very similar to those obtained the first season.

(*h*) High mortality in early stages.

The experience of last year was repeated this season in the great mortality among the seedlings commencing from about the third week. Careful dissections of the root-systems at frequent intervals showed that this resulted from a poor development of the early roots. It is hoped to be able to rectify this by a careful selection of parents both on the sugarcane and the sorghum sides.

(*i*) Future work.

It can now be claimed that this hybridisation is likely to yield short-duration canes with juices comparing not unfavourably with that of the standard canes. It is perhaps doubtful if into a six-month cane it would ever be possible to build yields associated with that of 12 to 24 month crops of cane. It needs, however, to be mentioned here that so far only one variety has been used as parent on either side, *viz.*, P. O. J. 2725 and *Sorghum Durra* Stapf. Improvements in tonnage could reasonably be expected from the employment of more vigorous parents on both the sugarcane and the sorghum sides. We are probably only at the beginnings of this line of work, and it may be some time before all the desired characters are worked into these short-duration canes.

III. SUGARCANE BREEDING (SUB-TROPICAL TYPES).

(*a*) The breeding programme.

The bulk crossings during the year consisted of Co. 213×Co. 244 and P. O. J. 2725×Sorghum. The former was done as it had yielded a few canes of considerable promise in North India ; the latter was done to confirm and further to exploit the possibilities of this new combination. Other cross-pollinations were made on a small scale to obtain preliminary information on the resultant types of seedlings, with the object of repeating the promising ones on a bulk scale.

(*b*) Selection and rejection of seedlings and parents.

The selections during the year were based on the performance of the canes under three different sets of soil conditions. The combination Co. 281×Co. 290 has yielded promising types ; and it is proposed to repeat it on a bulk scale in future years. The utility of Co. 214 as a parent for introducing early maturity and good sucrose has again been proved.

(*c*) Germination of sugarcane seeds at Karnal in the Punjab.

From the time of the Indian Sugar Committee in 1920 the writer of this report has been pleading for a Sub-station to Coimbatore in sub-tropical India for the obvious advantages that would result from such a station to sugarcane breeding in India. This was realized during the year; and a Sub-station on a five-year basis was started at Karnal with the funds sanctioned by the Imperial Council of Agricultural Research. This Sub-station under Mr. G. V. James has succeeded in germinating both crossed and selfed seeds at Karnal. For this sowing, the seeds had to be preserved for about six months in an atmosphere of CO_2. Periodic sowings of cane seeds are being made at Karnal to find out the best time for satisfactory germination and healthy growth of the young cane seedlings.

(*d*) Despatch of sugarcane seedlings to North India.

In view of the good performance of Coimbatore canes in the provinces, many of the provinces had applied to the Imperial Council of Agricultural Research for funds to test the Coimbatore productions at an earlier stage in their life-history than at present. The current practice has been to grow the new seedlings for a year or two at Coimbatore and distribute to the provinces cuttings of the promising canes. In connection with an investigation at the Sugarcane Research Station, Shahjahanpur, United Provinces, a batch of seedlings from Coimbatore had to be transported to Shahjahanpur some time after germination. To meet this demand, 5,000 seedlings of Co. 213 × Co. 244 were pricked into pans, specially treated to stand the 2,500 mile journey and despatched by rail during April 1931. The treatment consisted of two additional transplantings with the associated trimming of leaves and roots to induce early cane formation and hardening of the seedlings, as they stand adverse conditions better after cane formation has commenced.

(*e*) Breeding canes against disease.

Scientists visiting the Station from tropical countries had expressed satisfaction at the comparative freedom from disease of the cane crops at the Station. The latest was Dr. H. L. Lyon, Consulting Pathologist at the Experiment Station, Hawaii, who stayed at the Station for ten days and spent considerable time amongst the canes on the look-out for diseases. This comparative health of the plots is very likely attributable to the kind of parents employed at Coimbatore.

During the year there was a very severe attack of *Pyrilla* on cane crops both in the Punjab and the United Provinces. Certain of the Coimbatore seedlings have shown comparative freedom, demonstrating the utility of breeding against this pest. The best method of breeding against any particular disease or pest would appear to consist in choosing a locality most liable to it, growing a very large number of seedlings from carefully chosen parents and picking out those that are highly resistant, if not immune.

(*f*) Intergeneric hybrids with sugarcane.

Encouraged by the success with sorghum, arrows of P. O. J. 2725 were dusted with pollen of *paddy* (*Oryza sativa*), *cambu* (*Pennisetum typhoideum*), *maize* (*Zea Mais*) and bulb grass (*Cyperus roburdus*). The pollen of *maize*, *cambu* and *Cyperus* were noticed to germinate on P. O. J. 2725 stigmas; but the pollen tubes of the last would not penetrate into the style tissues.

(*g*) Breeding technique.

Owing to a shortage of earthen seed pans as the result of large sowings during the season, Botanical Assistant M. R. Ry. R. Thomas, Avl., improvised flats by erecting a six-inch clay wall over and along the borders of corrugated zinc sheets. After spreading a thin layer of sand on the zinc sheets, these were filled with equal parts of horse dung and sand and cane seeds sown on the surface. These proved quite a success, the sand combined with the corrugations of the zinc sheets ensuring good drainage. It was found easier to transplant seedlings from such improvised flats by breaking the clay wall and working from the sides.

(*h*) Controlling time of arrowing.

Experiments at controlling time of arrowing by application of different manures were repeated during the year, but the results were not as satisfactory as in the previous season probably owing to abnormal weather conditions during the year.

IV. OTHER INVESTIGATIONS.

(*a*) Forms of Saccharum spontaneum.

As indicated in the previous report, three Indian forms of *Saccharum spontaneum* and *Glagah* (the Java form of *Saccharum spontaneum*) were crossed with the same mother P. O. J. 2725, to observe differences in the types of seedlings produced. There is little doubt that there are more than one form of this species, each transmitting different characteristics when crossed with *Saccharum officinarum*.

(*b*) Sporting in Co. 213.

Certain interesting striped sports were obtained from Co. 213. Further propagated, certain of these sported back to the original Co. 213. A very thin and inferior type of sport has also been obtained as a bud sport from Co. 213. This work by Botanical Assistant M. R. Ry. R. Thomas shows that the material of Co. 213 will need to be watched at the time of planting so as to eliminate inferior bud sports.

(*c*) Periodic studies.

The periodic studies of popular Coimbatore canes mentioned in the last report are being continued this year and with fairly confirmatory results.

V. RESEARCH AND INVESTIGATIONS BEARING MAINLY ON THICK CANE BREEDING.

(N. L. Dutt, M.Sc.)

(*a*) Breeding and selection.

The crossing operations were affected to a certain extent by the unusually heavy rains during the season. A fewer number of varieties flowered as compared to the previous years. The crosses made on a bulk scale were : Vellai×P. O. J. 2878, Co. 359×P. O. J. 2727, P. O. J. 2725×Co. 290, P. O. J. 2878×Co. 243 and B. 6308×Co. 290. Besides the above, fifty-two other combinations were made but on a small scale, to ascertain the type of seedlings obtained. A feature of the hybridisation programme was the utilization as parents of certain seedlings produced at this Station.

Over 200,000 seedlings were raised, out of which about 80,000 were transplanted to the first ground nursery, and from among these 17,300 vigorous seedlings were grown for the full year test. The number of seedlings raised and transplanted during this season is higher than those of previous years. From the 1929-31 seedlings, 750 seedlings were selected based on their growth and habit characters and chemical analysis. Out of these, 251 were finally selected for further testing.

The first batch of eight Co. seedlings produced at the Thick Cane Area was distributed during the year to various provincial experiment stations in India for trial. The seedlings are Co. 358 to Co. 365 and were despatched to nine experiment stations in the thick cane-growing tracts, and four of the seedlings, *viz.*, Co. 358, Co. 360, Co. 361 and Co. 362, to four Government farms in the Punjab for trial as chewing canes. The parentages of these are given elsewhere in the report.

(*b*) Nuclear behaviour in the sugarcane.

The vegetative and generative nuclei were successfully stained with aceto-carmine in the pollen grains and also in the pollen tubes cultured artificially. The vegetative nucleus took a rather faint stain, while the male nuclei were stained deeply. The observations on nuclei were made on seventeen sugarcane varieties and also on *Saccharum spontaneum* and *Saccharum Narenga*. In all the sugarcane varieties examined and in *Saccharum spontaneum* the generative nucleus was found to have already divided into two male nuclei even 24 hours before the shedding of pollen. In a few pollen tubes of B. 3412 and in a few grains also, four male nuclei were noticed. This is rather unusual though not unprecedented as Strasburger noticed four male nuclei in *Camassia Fraseri*, but this is perhaps the first occasion that four male nuclei have been observed in the sugarcane. It may be mentioned that the four male nuclei have so far been observed only in one variety, *viz.*, B. 3412 and in no other. (Plate III, fig. 2.)

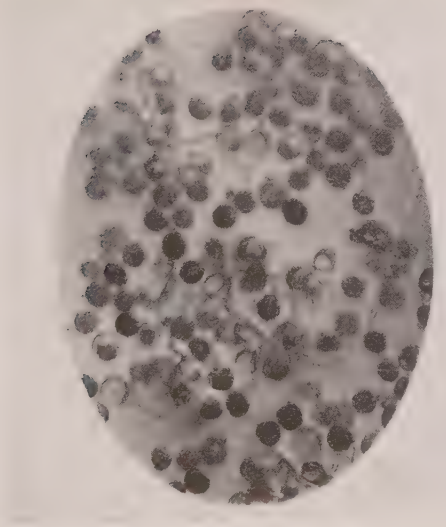

Fig. 1. Germination of Co. 285 pollen after storage for seven days.

Fig. 2. Four male nuclei in the longer pollen tube. The shorter one is normal. Variety B. 2341.

(*c*) Storage of sugarcane pollen.

The previous attempts to prolong the viability of sugarcane pollen did not prove satisfactory as the pollen invariably caked. The experiments on maintaining definite relative humidities and keeping pollen in vaccuum were repeated, but without success. After some experimentation it was found that sugarcane pollen kept best if placed in a petri dish containing a small quantity of $CaCl_2$—at the rate of 10 grm. per 1,000 c.c. of space—and covered at top with another petri dish, care being taken so as not to cut off outside air absolutely. The petri dish was then kept at a temperature ranging from 8° to 13°C. Kept in this manner, 7 days old Co. 285 pollen gave 12 per cent. germinations and was uncaked. (Plate III, fig. 1.)

(*d*) Controlling time of flowering.

The experiments mentioned in the previous report, *viz.*, (1) in which the varieties B. 6308 and P. O. J. 2725 were subjected to sub-normal day-length periods, and (2) in which these varieties were exposed to the vapours of ethylene chlorohydrin were inconclusive as neither the controls nor the treated canes flowered owing to abnormal weather conditions during the season. It is proposed to repeat these experiments.

Besides the above, experiments have been laid down to ascertain the effect of etiolation and of topping the five months old plants, on the time of arrowing.

(*e*) Duration of stigma receptivity.

In these experiments, in addition to the varieties taken last year, P.O.J. 2725 was also included. It was observed that on such stigmatic branches as had not completely dried, there were germinations when pollen was dusted on 8, 9, 10 and 11 days old stigmas of P. O. J. 100, Vellai, P. O. J. 2364. P. O. J. 2725 and B. 6308 were emasculated 24 hours before opening and the fresh pollen dusted. The pollen was observed to have germinated.

(*f*) Germination in thick cane seeds.

The experiments reported previously were repeated for confirmation. It was again found that the soil-fluff mixture gave the largest number of germinations ; with seeds soaked in 0·1 per cent. orthophosphoric acid and those soaked in water 15 hours before sowing, coming next in order.

Sixteen different combinations were made to ascertain the effect of the pollinating parent on seed germination. Six of these represent those in which reciprocal crosses were also made. It was found that P. O. J. 2878 gave better germinations when used as a female parent than as a male. In the case of B. 6308 and Vellai a larger number of germinations were obtained when crossed with D. 74 than when thin or medium canes like Co. 243 and Co. 290 were used as pollinating parents.

(*g*) Miscellaneous.

Crossed sugarcane seeds were exchanged with Hawaii and a consignment of seeds sent to Australia on request.

Seeds of seven crosses made at Manjri were received. Germinations were obtained in only two of these, *viz.*, (1) P.O.J. 2878×*Saccharum spontaneum* and (2) P. O. J. 2878×Sealy seedling. The percentage of germination was less as compared with that from crosses made at Coimbatore, in which the same female parent was used.

In response to a Questionnaire from the Chairman, Section on "Sugarcane Varieties," International Society of Sugarcane Technologists, replies bearing on the work at the Thick Cane Area were forwarded to him.

VI. PERFORMANCE OF COIMBATORE SEEDLINGS.

During the year there was a further spread of Coimbatore canes into cultivation in various parts of sub-tropical India, the later productions taking the place of the earlier distributions as further improvements. In the Punjab Co. 285 is steadily taking the place of Co. 205 in both the *barani* (unirrigated) and *chahi* (irrigated) areas. In the United Provinces even such a recent production as Co. 290 appears likely to be replaced in the near future by numbers above 300.

Over the greater part of sub-tropical India the term 'improved cane' is getting to be synonymous with 'Coimbatore cane.' In the United Provinces alone the extra profit to the growers is computed at over five and a half crores of rupees per annum or over four million pound sterling. The annual expenditure on the Coimbatore Station is hardly a five-hundredth of this amount. Besides the United Provinces, the Punjab and Bihar are the two provinces where the Coimbatore canes have spread a great deal in cultivation with similar profit to the cultivators.

During the year, Mr. N. L. Dutt was able to distribute for trial the first batch of Coimbatore seedlings of the thick or tropical type.

Coimbatore canes are getting further recognition in foreign countries. Co. 281 has recently been released for public use in Louisiana on account of its earliness, high sugar content, straight growth, superior yields and greater resistance to cold than many other P. O. J. canes. This cane has proved resistant to flooding in Florida and immune to leaf spot disease in Natal. Co. 290 is reported doing 'exceptionally well' in Natal and is to be distributed to the planters next season.

VII. RECEIPT AND DESPATCH OF CANES.

Sixteen cane varieties were received from foreign countries—the United States of America, Java, Barbados and Natal. This includes *Saccharum robustum*—perhaps the most interesting of the collections made by the aeroplane expedition to New Guinea organized by the Government of the United States of America under Dr. E. W. Brandes. The Station is indebted to Dr. Brandes for this kindness.

Over thirty parcels of cane material—mostly of Coimbatore seedlings —were distributed to Natal, Australia and Hawaii, and about one hundred and fifty parcels to various stations in India.

VIII. PARENTAGES OF COIMBATORE SEEDLINGS.

Parentages of seedlings raised to the status of ' Cos ' during the year are given in Table II. It is proposed to give such parentages in all future reports, as frequent enquiries are being received for such information.

Table II.

Parentage of Co. canes.

Seedling Number	Parentage
Co. 338, Co. 339, Co. 340	Co. 213 × Co. 214.
Co. 341, Co. 342, Co. 343, Co. 344, Co. 345, Co. 346, Co. 347	Co. 281 × Co. 223.
Co. 348	Co. 214 selfed.
Co. 349	P. O. J. 2725 × Co. 243.
Co. 350	Co. 213 × Co. 281.
Co. 351, Co. 352, Co. 353, Co. 354, Co. 355, Co. 356, Co. 357	P. O. J. 2725 × *Sorghum Durra* Stapf.
Co. 358	P. O. J. 2727 G. C. (self or possible cross with S. W. 111)
Co. 359	Co. 213 unbagged self.
Co. 360	P. O. J. 2725 × Q. 116.
Co. 361	P. O. J. 2725 × B .3412.
Co. 362	Vellai × D. 74.
Co. 363	Maur. 1237 × Q. 813.
Co. 364	P. O. J. 2725 × Fiji B.
Co. 365	P. O. J. 2725 × Q. 813.

IX. THE FARM.

The Farm passed through a period of drought owing to the failure of the south-west monsoon. This was followed by very heavy rains in October resulting in floods and consequent damage to crops at the Station. The Rest House, the newly constructed engine shed and pump chamber and portions of the seedling house went under water, and the roads were breached in many places.

X. TRAINING OF STUDENTS.

Mr. R. Madhava Row, B.A., was admitted as a post-graduate student for one year on the 5th November, 1930. He however terminated his course of studies on the 4th of July, 1931, to join the Ph.D. course in London.

Mr. A de Sorney, who spent three months at Coimbatore as a research student, has been placed in charge of sugarcane breeding in Mauritius.

XI. MISCELLANEOUS.

Various constructions were completed during the year; such are the combined irrigation and water supply scheme, installation of a gas plant and threshing floor.

Visitors during the year included Dr. H. L. Lyon, Consulting Pathologist, Experiment Station, Hawaii, Mr. J. Pirie from Gambia and Dr. Keen, Director of the Imperial Institute of Agricultural Research, Pusa.

XII. PROGRAMME OF WORK FOR 1931-32.

Major.

The breeding of medium canes will be continued with the object of securing further improvements or covering new tracts.

Intergeneric hybridisation between sugarcane and sorghum as well as with other cereals will be continued to fully exploit the possibilities in this line of work.

The breeding of thick canes to suit the requirements of the thick cane-growing tracts of India will be carried on.

Further attempts will be made to improve the breeding technique and to secure greater germination among thick cane seeds.

Minor.

Studies in sugarcane pollen, germination of cane seed and controlling time of arrowing.

Periodic studies of the growth phases of sugarcane varieties and seedlings, including periodic root dissections and shoot studies.

Morphological studies of sugarcane varieties (including flowering habits and floral characters), seedlings and wild *Saccharums*.

XIII. PUBLICATIONS.

(1) Venkatraman, T. S., and Thomas, R. . Coimbatore Seedling Canes, 281 and 290, described and illustrated. *Agriculture and Live-stock in India*, Vol. I, Pt. II, p. 128.

(2) VENKATRAMAN, T. S., and THOMAS, R. . Method of growing Sugarcanes for Special Studies. *Agriculture and Live-Stock in India*, Vol. I, Pt. III, p. 327.

(3) VENKATRAMAN, T. S., and THOMAS, R. . Sugarcane-Sorghum Hybrids, Part I, General Outline and Early Characters. Sent up for publication.

(4) DUTT, N. L., and KRISHNASWAMI, M. K. A Preliminary Note on Stigma Receptivity in certain Sugarcane Varieties. *Indian Journal of Agricultural Science*, Vol. I, Pt. II, p. 286.

REPORT OF THE SECRETARY, SUGAR BUREAU.

(Up to 31st March, 1931.)

I. PREFATORY.

Mr. Wynne Sayer held charge of the office of the Secretary, Sugar Bureau, up to 18th March 1931 ; Rao Sahib Kasanji D. Naik then acted as Secretary until March 31st, when the office and records were transferred to the Sugar Technologist, Imperial Council of Agricultural Research. The present report has, to a large extent, been drawn up by Mr. Srivastava from the records in his possession.

The Bureau continued to collect information relating to the sugar industry in India and abroad and to make it freely available to the public.

II. AGRICULTURAL.

The practical work on cane has, as previously, been done by the Agricultural Section at Pusa, as the Secretary, Sugar Bureau, was also officiating Head of the Agricultural Section. The Bureau was in close touch with the work, and with the advice given to the Government Sugarcane Expert, at Coimbatore, from time to time, in the selection of new types suitable for varying requirements. The steady increase in the area under improved Coimbatore canes and the higher tonnage yields of these varieties and the steady rise in the recovery percentage of sugar clearly indicate the progress made by the agricultural side of the Indian sugar industry.

Tonnage experiments were carried out with Co. 213 and Co. 210 to ascertain which of these two standard varieties is better for the light soils of the White Sugar Tract.

Multiplication of Co. 285, including its tonnage experiment, was done in order to replace Co. 205 which has been discarded by the mills.

Tonnage experiments were carried out with Co. 223 and Co. 210, one being the standard variety in the Punjab and the other in North Bihar.

Manurial experiments with nitrate of soda and sulphate of ammonia as top-dressing, in addition to standard manuring, were also carried out.

Details of the results obtained have been given in the Report of the Imperial Agriculturist.

III. INDUSTRIAL.

The number of sugar factories in India increased by one during the year under report as the projected factory in the Punjab started working during the season 1930-31. As in the past, the Bureau kept in touch with all the sugar factories and gave advice when asked for. Production figures for the factories making sugar direct from cane during the season 1929-30 as well as for the refineries for the year 1930 were obtained ;

and consolidated statements of sugar production were compiled and published in the *Indian Trade Journal* and *Agriculture and Live-stock in India*. The production of sugar direct from cane in the cane-crushing season 1929-30 amounted to 89,768 tons compared to 68,050 tons in 1928-29, and the total quantity of sugar refined from *gur* fell from 31,038 tons in 1929 to 21,150 tons in the *gur* refining season 1930. Thus the total production of sugar in India for the combined cane and *gur* seasons was 110,918 tons in 1929-30 as against 99,088 tons in 1928-29. The last five seasons' average percentage recovery of sugar direct from cane in the sugar factories show that there is a steady improvement in all the provinces of India. This will be clearly seen from the following table :—

Name of Province	1925-26 recovery p. c.	1926-27 recovery p. c.	1927-28 recovery p. c.	1928-29 recovery p. c.	1929-30 recovery p. c.
Bihar and Orissa . .	7·98	8·67	8·80	8·61	8·90
United Provinces . .	7·88	7·93	8·07	8·37	9·00
Bombay, Madras and Burma.	8·98	10·26	10·09	9·93	10·12
TOTAL FOR INDIA . .	8·07	8·49	8·62	8·59	9·07

Another table showing the production of sugar direct from cane and from refining *gur* or raw sugar during the last eleven seasons is given below :—

Production of sugar.

Season	Direct from cane	Season	Refined from gur	TOTAL
	Mds.		Mds.	Mds.
December 1919 to April 1920 . .	6,28,920	January to December 1920.	12,11,274	18,40,194
December 1920 to April 1921 . .	6,69,291	January to December 1921.	13,24,645	19,93,937
December 1921 to April 1922 . .	7,53,638	January to December 1922.	13,03,433	20,57,071
December 1922 to April 1923 . .	6,51,415	January to December 1923.	13,68,126	20,19,541
December 1923 to April 1924 . .	10,44,856	January to December 1924.	15,38,304	25,83,160
December 1924 to April 1925 . .	9,21,950	January to December 1925.	9,16,121	18,38,071
December 1925 to April 1926 . .	14,45,061	January to December 1926.	10,47,420	24,92,481
December 1926 to April 1927 . .	17,16,426	January to December 1927.	15,91,997	33,08,423
December 1927 to April 1928 . .	18,45,752	January to December 1928.	14,16,926	32,62,678
December 1928 to April 1929 . .	18,52,322	January to December 1929.	8,44,845	26,97,167
December 1929 to April 1930 . .	24,43,486	January to December 1930.	5,75,709	30,19,195

During the year under report the Government of India increased their revenue duties on all imported sugar by Rs. 1-4 per cwt. for each grade of sugar.

The revised duties are as under —

Sugar excluding confectionery :—

	Rs. A. Per cwt.
(1) Sugar, crystallised or soft 25 Dutch standard and above	7 4
(2) Sugar, crystallised or soft inferior to 23 Dutch standard but not inferior to 8 Dutch standard	6 12
(3) Sugar below 8 Dutch standard and sugar candy	*Ad valorem* 25% *plus* 2 12 per cwt.
(4) Molasses	*Ad valorem* 25%

Figures showing the world sugar production of beet and cane raw value as published by Dr. Mikusch are given below :—

1928-29	28,898,000	metric tons.
1929-30	28,471,000	
1930-31	29,682,000	„ „ *estimated.*

In the pre-war year the world's production was :—

1913-14	19,948,000	metric tons.

It will be seen that the world's sugar position during the year under report was one of over-production.

The stocks on 1st April in Europe (11 countries), United States (all ports), Cuba and Java as given by Herr F. O. Licht are as under :—

1st April 1929	6,900,607	metric tons.
1st April 1930	7,909,429	„ „
1st April 1931	9,704,500	„ „

British India imported 901,278 long tons of sugar valued at Rs. 10,53 lakhs during the year 1st April, 1930, to 31st March, 1931, as against 939,584 tons valued at Rs. 15,51 lakhs in the preceding year and 868,800 tons valued at Rs. 15,85 lakhs in 1928-29.

Imports from Java amounted to 851,000 tons in 1928-29 but fell to 781,000 tons in 1929-30. This drop was due to the competition of beet sugar, of which 131,000 tons were imported in 1929-30 as against 8,400 tons in the preceding year. The imports of Java sugar during the year 1930-31 amounted to 810,000 tons and beet to 78,119 tons.

Average prices of Cawnpore Special and Java White sugar in the Cawnpore market from July 1930 to June 1931 are shown in the following table :—

Date	Cawnpore Special	Java White
	Rs. A. P.	Rs. A. P.
July 1930	10 0 0	10 6 0
August 1930	10 0 0	..
September 1930	10 1 6	..
October 1930	10 0 0	10 3 3
November 1930	9 13 0	9 15 0
December 1930	8 13 0	9 12 10
January 1931	8 8 6	9 13 6
February 1931	8 12 6	10 2 7
March 1931	9 0 0	10 6 0
April 1931	8 14 0	10 3 11
May 1931	8 11 6	10 8 0
June 1931	8 8 0	10 4 0

From the above it will be seen that the monthly average prices of Cawnpore Special sugar have been steadily decreasing during the year 1930-31 whilst the prices of Java White were fluctuating.

IV. STATISTICAL.

Work on the statistical side comprised the collection of :—

(1) Import and export figures for India and for the principal sugar-consuming countries of the world,

(2) Figures of area under sugarcane and beet in India and foreign countries,

(3) Figures for costs of production of *gur* and sugar and the consumption of sugar in various countries of the world.

A large number of enquiries on the statistical side was received throughout the year from the public, Government officers, the Imperial Council of Agricultural Research, and the Indian Tariff Board, and all available information was supplied to them.

Price quotations for various grades of *gur* or *jaggery* were obtained from the various *gur* centres in India, and arrangements were made for their publication in the *Indian Trade Journal*. The Director-General of

Commercial Intelligence and Statistics, Calcutta, was also supplied with quotations of Java White sugar at Sœrabaya and of Indian factory made sugar at Cawnpore as well as figures of stocks of sugar at the principal ports in India for publication in every weekly issue of the *Indian Trade Journal.*

The Bureau continued to furnish the Department of Commercial Intelligence and Statistics, Calcutta, with brief reviews of the sugar crop conditions in the world for incorporation in the all-India sugarcane crop forecasts published in August, October and February. The Bureau also continued to contribute notes to the *Indian Trade Journal* on production, imports and exports of cane and beet sugar crops of the world. A review of the sugar trade in India is also published by the Bureau annually.

The Sugar Bureau has been conducting for the last nine years the Sugar Cable Service on a self-supporting basis, the cost of the service being met by the firms or individuals who obtain the benefits of the Service. During the year under review, the Service showed a loss. The chief function of this Service is to obtain and distribute early and reliable reports of crop and market conditions in the principal sugar-producing and sugar-consuming countries of the world. The subscribers are from Bombay, Karachi, Cawnpore, Calcutta and Madras.

V. MISCELLANEOUS.

Library. During the period July 1930 to March 1931, 127 volumes were added to the library. These were received either by purchase, exchange, or free supply or by binding loose copies of the periodicals obtained in the library. The library was consulted by those interested.

Publications. Thirty-four notes giving statistical information were published in the *Indian Trade Journal.* Besides these, four notes were published in the *Agricultural Journal of India* and one in *Agriculture and Live-stock in India.*

Museum. Samples of Indian factory made sugar were obtained in the season 1929-30 and these replaced the old ones already exhibited in the Museum. Foreign sugar samples are also maintained.

VI. CONCLUSION.

The year under report was marked by severe depression in the sugar markets of the world. The attempt of the more important sugar-producing countries to bring relief to the industry has to some extent borne fruit in the evolution of the Chadbourne Restriction Scheme. The Indian sugar industry continues to show signs of progress. Its efficiency is steadily increasing on the agricultural as well as the manufacturing side. The raising of the import duty on all grades of sugars by Rs. 1-4 per cwt. has provided much needed relief to the industry.

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